SCIENCE

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THE MECHANICAL, THE HISTORICAL AND THE STATISTICAL

I. PRACTICAL PURPOSE OF THIS MEETING

THIS meeting is the outcome of conversations which resulted from the recent book of Dr. Henderson on "The Fitness of the Environment." Yet this company is not called for the sake of discussing, on the present occasion, that book, or any of the scientific problems which it more directly considers. The connection, then, between Dr. Henderson's book and this evening's undertaking needs some explanation. As you know from the wording of the call to which you have so kindly responded, one principal purpose which I have in mind as I address you is practical. I shall ask you, before the evening is done, to give some thought to the question: Is it advisable for us to meet again occasionally, as opportunity offers, in order to discuss some questions of common scientific interest. You represent various departments of research. Is it worth while for you, or for some of you, at your own pleasure, to come together in such a way as the present one, in order to take counsel about different problems which belong, not only to a single science, and not only to some special group of sciences, but also to the realm which is common to a decidedly wide and varied range of scientific inquiries?

My part in this evening's discussion is determined by this practical question. I can not come here as a representative of any one department of research in natural science. I am limited in my present undertaking to such an appeal as a student of philosophy may have a right to address to

a company of scientific men, when he wishes to ask them a practical question whose answer concerns them all.

The only justification which I have for addressing you is that the habits of a student of philosophy, and, in particular, of a student of logic, make him sensitive to the value of a comparative scrutiny of the methods, the conceptions and the problems of various sciences.

If the main topic of the evening is a question relating to the practical value of some new mode of cooperation, in which a number of representatives of different departments of scientific research are to be asked to take part, the student of philosophy may possibly serve as a sort of traveling agent. For the kind of cooperation to which I have been asked to invite your attention would involve, if it succeeded, certain journeys which some of you might thereby be induced to make into the provinces of your colleagues. Widely traveled though all of you are, these journeys may lead occasionally to novel incidents, and may please or arouse you in new ways. My business, I say, is to act this evening merely as such a tourist agent, describing and praising as I can the new kind and combination of journeys to which my agency proposes to invite you.

Philosophy itself, in so far as it is a legitimate calling at all, may in fact be compared to a sort of Cook's bureau. Its servants are taught to speak various languages—all of them ill—and to know little of the inner life of the numerous foreign lands to which they guide the feet, or check the luggage of their fellow-men.

But if new comparative studies of the ideas of various and widely sundered provinces of research are to be carried out at all, Cook's agents, tedious as they often are, have their part to play. Regard me, then, if you wish to vary the name, as representing this evening some bureau of university travel.

II. Preliminary View of the Theoretical Problem of This Paper

Speaking seriously, let me say that my task, upon its theoretical side, involves undertaking to present to you, in a perspective which may prove to be not wholly familiar, an outline sketch of certain conceptions and methods which actually belong to widely various sciences. These conceptions and methods in some measure concern you all, and, in our day, they are undergoing various changes, and are being applied to new problems.

The problems of each science are its own affair; but they also concern the whole body of scientific workers. To look over a somewhat wide range of scientific work, not for the sake of contributing to the researches of any one special science or group of special sciences, but for the sake of studying for their own sake some of the most general ideas and methods that are used by various scientific workers—this is, at the present time, a legitimate undertaking, and, in view of what has already been done, and is now under way, is not a hopeless undertaking.

The perspective in which such a study may place the problems of other people may help them to understand one another better. My task, on its theoretical side, is limited this evening to a few such general methodological remarks. These remarks may then lead us back to our practical question.

III. The Problem of Vitalism

The name vitalism is often given to those doctrines which have used the hypothesis that the phenomena of living organisms are due to some process which is essentially identical in its nature with the process ex-

emplified by our own conscious voluntary activities. We deliberate, plan and choose. It seems to us as if certain things and occurrences in the world were due to these our plans and choices, and are different from what they would be were our will not a factor in the world-process. On the other hand, some things and events in the natural world—notably the recurrent movements of the heavenly bodies, and the processes which attend the workings of machines, seem to us to be, in some or in many respects essentially different from the processes which result from our plans, our choices and our voluntary deeds. What is called a mechanical theory of nature, or, more generally still, materialism, undertakes to account for the vital processes, for the activities of organisms, by supposing that they too are not essentially different from the other material processes, and that they really exemplify the same natural laws which the movements of the heavenly bodies and the workings of machines illustrate.

The contrast between vitalism and materialism is, in the history of science and of philosophy, very ancient. The Greeks began with doctrines which were, in a somewhat confused way, both materialistic and vitalistic. The natural world was viewed as, in one of its aspects, a sort of machine, a chariot whose mechanical movement was an essential feature of its very being. The natural world was also regarded as through and through alive—a world of love and strife, of mixing and of sundering, of wisdom and of something resembling contrivance.

To this early Greek vitalism, which had various forms, the materialism of Democritus opposed a mechanical theory of nature which was much more ingenious and considerate than were the earliest forms in which the machine-like aspect of nature was described. On the whole, however, vitalism, the doctrine that nature acts not in vain, but in an essentially planful and designing way, was predominant in Greek thought.

The greatest Greek vitalist was Aristotle. Materialism remained in the background of ancient thought, and was destined to be revived, and to take on the form of the modern mechanical theory of nature, only after the beginnings of the new science in the seventeenth century of our era.

These ancient problems as to whether nature is rather a mechanism or an expression of something which essentially involves or resembles wisdom and contrivance, are certainly not questions which belong to any one natural science or group of natural sciences. From time to time, however, they come nearer to the surface of popular or of scientific discussion. The present is a moment when a certain interest in various forms of vitalism has once more become prominent in the discussions not only of philosophers and of leaders in popular inquiry, but of some professional students of the natural sciences of life as well.

I do not know how far it will prove to be interesting or profitable for you, as scientific men, to discuss, in your future meetings, if you have any future meetings, problems directly connected with vitalism, or with its old opponent, the mechanistic theory of the nature of life. I know only that when we mention such problems we call attention to one of the ancient boundary lines, or, as one may say, to one of the beaches where, in the realms of inquiry, sea and land come face to face with each other; so that two widely contrasting realms of nature here seem to clash. Here, then, the waves of experience tumble, and

the tides of opinion rise and fall. Here, then, for that very reason, and especially at this very time, new discoveries are likely to be made in especially impressive ways.

If you are to compare notes, it will therefore not be surprising to find that questions about the relations, the contrasts and the connections of life and of mechanism will become prominent in your discussions. My own preliminary remarks on the classification of scientific methods may well be guided, then, by some interest in the scientific processes which go on upon this old boundary line—this sea-beach—of opinion and of investigation, where the vast and doubtful seas of inquiry into the phenomena of life encounter, as it were, the firm land where the mechanical view of nature finds its best known illustrations.

IV. THE VITALISM OF ARISTOTLE

It will help us in our survey of our problems about the contrasting ideas and methods followed by the inorganic sciences on the one hand and the sciences of life on the other hand, if we next say a word about one aspect of Greek vitalism which is frequently neglected.

Life-processes in general resemble our own human voluntary processes, as we have said, in so far as any living organism seems to us as if it were guided by some sort of design, and as if, through a kind of wisdom or contrivance it adjusted means to ends. To say this, however, and even to believe that this seeming is well founded, and that, in some wise living nature really is planful, and does embody something of the nature of will, or of purpose—to assert all this is not yet to decide how close the real resemblance is between the teleology of nature and the choices and contrivances of a man who is planning and who is exerting his will.

As a fact there have been many vitalists who thought nature, and in particular organic nature, to be purposive, but who did not believe that nature is clearly aware of her own designs.

There have been many vitalists who conceived of nature as in some sense even divine in its skill, but who did not accept theism either in its primitive or in its more cultivated forms. The design argument in its later theological formulations is not any classic argument for vitalism. All this becomes manifest if you look for a moment at Greek vitalism, and, in particular, at the vitalism of Aristotle.

The Greek vitalists well knew that nature, however wise she seems to be, does not show signs of deliberating like an architect before he builds a house, or of piecing together her works as a carpenter devises a chest or a bed. For the Greek vitalist, and, in particular, for Aristotle, nature fashions, but not as a human mechanic fashions—piecemeal and by trial and error.

Nature's skill is (so such vitalists think) more like that of a creative artist, who does not pause to know how he creates. If ideas inspire the artist, he does not reflect upon what they are. Just so, while the being whom Aristotle calls God, who is conceived to exist quite apart from the world, is indeed self-knowing and is wisely self-observant, Aristotle's God is not the God of the later design argument. For he neither creates nor fashions the natural world. Nature, in Aristotle's opinion, is not God, and is not God's handiwork, but is, with a certain instinctive and unconscious wisdom, a sort of artistic imitator of God's wisdom. And this natural process of imitating the divine perfection by quickening a material world with a tendency to be fashioned after

a divine pattern—this process constitutes the life of the natural world.

The designs which nature expresses are therefore for Greek vitalism not the conscious designs of anybody—either God or man. They are the creative tendencies which embody themselves in the material world, by a process which we can best compare with the workings of instinct or of genius.

Now modern vitalism is far away from its Greek forerunners, but whenever, for any reason, vitalism becomes afresh interesting to any group either of philosophers or of scientific workers, it is well to remember that the contrast and the conflict between a mechanical view of nature and a vitalistic view has hardly ever been limited to the decidedly special and artificial antithesis between blind mechanism, on the one hand, and conscious or deliberative design, on the other hand. For even our human art is, as Aristotle remarks, partly guided by a skill which is not conscious and is not deliberate. That which, in recent years, Bergson has called élan vital—the creative vital power, was well known, in their own way, to the Greeks.

Different as Bergson's vitalism is from that of Aristotle, the ancient view and Bergson's vitalism have in common the belief that life means a process of which the instinctive skill and the artistic genius of man give examples. The problem of vitalism is always the problem as to how such unconscious skill, such undeliberative art, is made possible.

And so, even in this sketch of the varieties of scientific method, I shall in passing name to you one way in which some of the newest hypotheses may enable us to face, and perhaps in some measure to clarify, the problem as to how this stimulation of conscious designs by processes which are themselves unconsciously or, so to speak, blindly wise, is a possibility in the natural world.

V. THREE TYPES OF KNOWLEDGE: THE HISTORICAL, THE MECHANICAL AND THE STATISTICAL

So much must suffice as an introductory word regarding those problems about vitalism and mechanism which have recently been revived, and have brought us together. Herewith we are ready to proceed to our classification of the conceptions and the methods which have been and which may be used in dealing with such a range of problems as is this.

The attempt to sketch in a preliminary way what these conceptions and methods are can be preserved, I think, from vagueness, if I begin by using the guidance of a man of whom you all are accustomed to think as a true natural philosopher—one who was possessed of a very exact sort of scientific knowledge, and who was a great scientific discoverer. He was also very fond of a comparative study whereby he lighted up his own researches through thoughts that came to him from far-off fields. I refer to Clerk Maxwell. In a paper whereof some fragments are printed in his biography, as well as in various remarks in his published writings, Clerk Maxwell more than once used the classification of scientific knowledge which I shall here employ for our present purpose. Natural science, in so far as it studies the processes of the natural world, has three kinds of objects with which it deals. And it adjusts itself to these three kinds of objects by methods which, in each of the three fields thus defined, vary widely from one another; while in each of the three fields both the conceptions and the methods used have much in common, and much too whereby each of the three fields differs from the others. The three sorts of ob-

jects are: (1) Historical objects, (2) mechanisms, and (3) statistically defined assemblages. The three sorts of methods are: The historical, the mechanical and the statistical.

Clerk Maxwell's few but momentous observations upon these three fields of scientific knowledge have a beautiful brevity, and show a fairly poetical skill of imagination whereby he finds and expresses his illustrations both of scientific ideas and of methods. I can not follow the master in his own skill. And I shall be unable to use his language. I must portray his classification in my own way, and must use my own illustrations.

If you wish to come into closer touch with this aspect of the master's thought, you may use the concluding passage of his famous elementary treatise on the "Theory of Heat," and several remarks in his article on "Atoms" in the ninth edition of the Encyclopedia Britannica. In addition I may refer you to the citations made by Theodore Merz in the eleventh chapter of Volume II. of his "History of European Thought in the Nineteenth Century" (pp. 599, 601 and 603).

Let me briefly review, with a few illustrations, this classification of the three fields and the three methods of natural science.

Science deals either with substantial things (such as atoms or organisms) or else with events. Let us confine ourselves here to the works of science in its dealings with natural events and processes. Science deals with the historical when its objects are individual events or complexes of events, such as is a single solar eclipse, or such as is the birth or the death of this man, or the performance of just this act of choice by this individual voluntary agent.

Science deals with the mechanical when its objects are the invariant laws to which all the individual events of some field of inquiry are subject, and when such invariant laws actually exist, and can be used to compute and to predict actual events. Thus, if the acceleration which every individual body belonging to a system of material bodies undergoes depends at every instant, in an invariant way, upon the spatial configuration of the system of bodies at just that moment, the system is a mechanical system—such, for instance, as a system of bodies moving in accordance with the Newtonian law of gravitation.

Science deals, in the third place, with the statistical, when it studies the averages in terms of which aggregates or collections of events can be characterized, and when it considers not the invariant laws, but the always variable possibilities that these averages will be subject to certain uniformities, and will undergo definable changes.

In brief, the object of historical knowledge is the single event, occurring, in the ideally simple case, to an individual thing. A free-will act or an observed eclipse serves as an example. The object of mechanical knowledge is the unchanging natural law under which every event of some type can be subsumed. Sometimes the object of mechanical science may be an individual event, but only in so far as, like the eclipse, it can be predicted by means of such an invariant law. The object of statistical knowledge is not the single event and is not the invariant law, but is the relatively uniform behavior of some average constitution, belonging to an aggregate of things and events, and the probability that this average behavior will remain, within limits, approximately, although always imperfectly uniform.

VI. Applications of this Classification

In view of this classification of the objects of scientific knowledge, you may see

at once that the issues between such doctrines as vitalism and a mechanistic account of nature appear, from the point of view of Maxwell's classification, in a somewhat unfamiliar perspective. For one need no longer merely contrast two views, the mechanical and the vitalistic. One now has a third and a mediating point of view to compare with both of them. The result is instructive.

Vitalism, whatever else it involves, always makes prominent some aspect of nature, and in particular some aspect of organic nature, such that this aspect is supposed to be, in some individual case, strictly historical. If an organism is due to a purposive process, if the reactions of an organism are, in any instance, events of the nature of conscious or of subconscious deeds—then something unique, historical and novel occurs whenever one of these vital processes is exemplified by an individual event.

On the other hand, if the mechanistic view of nature can exhaustively express the real facts, then the only natural events are of the type which the eclipses exemplify. The single events are, so to speak, points on a curve, selections from an ideal continuum whose constitution is definable in terms of an invariant differential equation.

But the third or statistical mode of viewing nature takes account of another aspect of the processes of nature. The world of the statistical view still contains events supposed to be unique and individual; but from the statistical point of view the main interest lies no longer in each event as it occurs, nor yet in its unique character. The statistical interest is directly concerned with a set or aggregate of events, with a discrete multitude of occurrences. These occurrences may prove to be examples of law. The statistical view is deeply interested in finding that they are examples of law. But the law for which the statistical method seeks is no longer a law that is ideally statable in terms of an invariant differential equation or in terms of any other timeless invariant. When found, the statistical law is an account of a collection of facts in terms of averages involving many events.

This account takes some such form as saying: "The average magnitude or velocity or size or range of the events of the class C is approximately V." Or, again, the statistical view succeeds when we can say: "A proportion which is approximately p of the events of the class a have the character b." Or finally, one expresses the statistical view when one is able to assert: "There is a probability q that c differs from d by not more than such and such an amount,—say X." All such generalizations, where the objects in question are living organisms, relate to events, but neither to merely historical single events nor to events subject to fixed laws. The statistical laws are probable and approximate laws about numbers of events.

Laws and probabilities, stated in some such form as the one just suggested, constitute the characteristic formulas of the statistical view of nature.

It is easy to illustrate how the statistical view contrasts with both the mechanical and the historical point of view by considering how each point of view applies to an event such as is expressed by the assertion: "A killed B."

For a strictly historical point of view this event, this homicide, is an unique occurrence—possibly a free-will act. It falls under moral and criminal laws, but these relate only to its value and its legal consequences. The interest of the case for a judge or a jury lies in its novelty—and in its uniqueness. For a strictly mechanical

view of things the killing resembles an eclipse. Unique as it is, it is supposed to have been essentially predictable. Perhaps if you had known the precise configuration and the accelerations of all the physical particles in the world at some appropriate moment, then this killing could have been calculated in advance. It is a mere case of a law—an eclipse, so to speak, of some sun—a point on some curve.

But for a statistical view the single killing of *B* by *A* is an event against which an insurance provision could have been made in advance—not because any mortal could have predicted whether or no *A* would kill *B*, but because the death-rate of men of *B*'s age and occupation can be statistically known with approximate and probable accuracy, so as to make a policy insuring *B*'s life a contract whose value is calculable, not on mechanical but upon statistical grounds.

Now you will easily recognize that the actual knowledge of vital phenomena which science possesses is, in the main, a statistical knowledge. It is the sort of knowledge which the mortality tables of the insurance companies exemplify. We know little of the history of individual organisms, and less of their mechanism, but we can and do study the statistics of groups of organisms. In such statistical terms heredity and variation are now constantly investigated. In such terms growth and disease, as well as death, economic prosperity and social transformations, financial and political processes, the geographical distribution of organisms and the gradual accumulation and change of the material as well as the mental products of civilization—in such statistical terms, I say, all such things come to be the objects of scientific description and explanation. To give an account of the special phenomena of life in terms of mechanism remains in practise a remote ideal, despite all the proofs that the vital processes, being subject to physical and chemical laws, must be, in some sense, if not wholly, then very largely mechanical in their nature. Life may be a case of mechanism; but its phenomena are best known to science in terms of statistical averages, of laws which hold approximately true regarding these averages, and of probabilities which are definable in such terms as are used when the insurance value of a life-policy is computed. The logic of the insurance actuary is essentially the same as the logic which is consciously or unconsciously used in dealing with all forms and grades of vital processes.

This general rule regarding the methods of the sciences of life is well known to you. For it is also known that, just as a mechanical theory of the details of the phenomena of life still remains a remote ideal, so too an historical knowledge of the individual events of the life of an organism is something which may possess upon occasion great moral or social or perhaps clinical interest, but can occupy but a part, and usually a very small part, of the interest of the sciences of life.

Into the study of human history itself, devoted as such a study naturally is to the sequences of individual events, natural science enters in so far as something of the nature of statistical knowledge is acquired. And therefore the use of deliberately statistical methods in historical study, the use which Dr. Woods has recently proposed—such a use, I say, is in principle nothing essentially opposed to methods long since inexactly and unconsciously employed. For the historiometry of Dr. Woods is in principle a legitimate extension and a logically legitimate refinement of the long since well-known disposition to explain human history in terms of "historical tendencies" and of "historical forces."

In fact, the term *tendency* is, in every exact usage which you can give it, an essentially statistical term. To say that *a* has a tendency to lead to *b* is to declare that a more or less certainly and definitely known proportion of events of the class *a* are followed by events of the class *b*.

To introduce statistics into historical study is simply to try to make some such assertions about tendencies exact.

The constant extension of the use of statistical methods in all the sciences of life is something as familiar as it is momentous. Its very familiarity, in fact, tends to blind the minds of many to its real importance. In truth, the statistical view of nature has a logic of its own. Its three fundamental conceptions, that of an average, that of approximation and that of probability, are indeed not the only fundamental categories of our thought, but they are conceptions which go down to the very roots of our own intelligence as well as of our voluntary activity. It seems increasingly plausible to assert that these three conceptions, while they certainly have their special province, still, within that province go down to the roots of that nature of things which our sciences are studying. At all events, I find it hard to exaggerate the importance of those methods and of those ideas of natural science which are definable in terms of approximation and of probability, in the modern sense of those terms.

When Clerk Maxwell made his threefold classification of scientific methods, he did so with his eyes well open to the fact that by the statistical view of nature, and by statistical methods in science he meant something much wider and deeper than is the mere commonplace that statistical tables can be made by the census bureaus, and can be used by the insurance companies, or applied to the discovering of various special laws of nature. Let me remind you of what Maxwell had in mind.

VII. THE STATISTICAL VIEW IN PHYSICS

Clerk Maxwell was a physicist. His greatest treatise was that upon electricity and magnetism. The theory of electricity and magnetism follows methods which illustrate the mechanistic way of dealing with the problems of nature. Maxwell defined a system of differential equations in terms of which certain elementary electromagnetic processes can be expressed. Assuming these equations to be true, one can compute the consequences of one's hypotheses, as Newton computed the consequences of supposing the law of the inverse squares to be true for a field of gravitative force. One can then compare the computed results with experience, and upon such computation and comparison with experiment one's method in this case depends. Such is an example of the essentially mechanical view of nature.

But Clerk Maxwell, working as he did at a time when the general theory of energy was in its period of most rapid development, was not content to confine himself to problems of the type of the theory of electricity. He also had his attention especially directed to those physical processes which are illustrated by the diffusion of gases, by the irreversible tendency of energy to pass over from available to unavailable forms, and by various analogous phenomena which can not be expressed in terms of the classic types of mechanical theories.

Following the initiative of Clausius, but developing along lines of his own, Maxwell thereupon worked out his kinetic theory of gases. It is that theory of which he is thinking when he distinguishes the statistical way of viewing nature both from the historical and from the mechanical view.

In fact, when the kinetic theory of gases first defines its swarms of molecules, with their countless paths and collisions, it appears to be viewing a gas simply as a complex mechanism; and in certain respects this seeming is well founded. But the logic of the theory of probabilities, which the kinetic theory uses in deducing the physical properties of gases from the statistical averages of collisions and free paths of the hypothetical molecules, is no longer reducible to the logic of mechanics. For the velocity, the path, and the collision of each individual molecule are all indifferent facts for this kinetic theory of gases; which devotes itself to the study of probabilities and of tendencies. And its methods are in part those which the procedure of the insurance actuaries exemplifies. The logic in question is one which in some respects still needs further elucidation. For even up to the present time the logic of the theory of probabilities is a controverted topic. But there are a few features of the situation about which nobody who looks carefully into the subject can retain, I think, any serious doubt.

First, then, the average behavior of a very large collection of irregularly moving objects has characters which are decidedly lawful, even although the laws in question are what may be called laws of chance.

The recent familiar use of statistical diagrams for illustrative purposes has made this law of chance more familiar to many classes of students than it was in the day when Maxwell wrote certain words, which you will find in his "Theory of Heat."[1] These words give you the very heart of the statistical aspect of nature.

> The distribution of the molecules according to their velocities is found to be of exactly the same mathematical form as the distribution of observations according to the magnitude of their errors, as described in the theory of errors of observation. . . . Whenever in physical phenomena some cause exists over which we have no control, and which produces a scattering of the particles of matter, a deviation of observations from the truth, or a diffusion of velocity or of heat, mathematical expressions of this exponential form are sure to make their appearance.

[1] Page 309 of the Appleton edition of 1875.

This, then, is in concrete form the law of random distribution, the form of iron necessity which one finds in the realm of chance.

All this law of chance variation was, of course, at that time no novelty, although the popular use of statistics has since made it more familiar. What was new, however, was the fact that when Maxwell computed the consequences which followed from supposing the existence of his swarm of colliding molecules with their chance distribution of velocities, he was able to deduce not only the principal physical properties of gases, but in particular those properties which, like all the phenomena which illustrate the second law of the theory of energy, are not expressible in terms of merely mechanical laws, unless these laws are applied to the case of a system complex enough to ensure that the velocities of its molecules shall approximate closely to this chance distribution.

Since Maxwell's time, the same theoretical methods have been applied to a vast range of physical phenomena, with the general result that the second law of the theory of energy is now generally regarded, by all except the extreme *Energetiker,* as essentially a statistical law. So viewed, the second law of energy becomes a principle stated wholly in terms of the theory of probability. It is the law that the physical world tends, in each of its parts, to pass from certain less probable to certain more probable configurations of its moving particles. As thus stated the second principle not only becomes a law of evolution, an historical principle, but also ceases to

be viewed as any mechanically demonstrable or fundamentally necessary law of nature. Whether nature is a mechanism or not, energy, according to the kinetic theory, runs down hill as it does for statistical and not for mechanical reasons. Energy need not always run down hill; and in fact would not do so if there were present in nature any persistent tendency, however imperfect, towards a suitable sorting of molecules. Maxwell suggested in his image of the demons sorting the atoms of a gas, how such a tendency might make energy run up hill instead of down, without the violation of any mechanical principle.

More recently Boltzmann, in his further development of Maxwell's hypothesis, pointed out how the theory of probability itself requires that, in the course of very vast intervals of time, there must occur some occasional concentrations of energy and some sensible unmixings—some reversals of the diffusion of gases, in case indeed the kinetic theories are themselves true. And still more recently Arrhenius has suggested that the nebulæ may furnish the conditions for the occasional if not the general reversal of the second law of the theory of energy. Of such speculations I can of course form no judgment. They interest us here only as examples of the logic of the statistical view of nature.

In sum, all these investigations have tended to this general result: If a law of the physical world does not appear consistent with the mechanical view of nature so long as you confine your attention to a single system of bodies, whose individual movements you follow and compute, this law may still become perfectly intelligible when viewed as the expression of the average behavior of a kinetic system complex enough to give an opportunity for the application of statistical laws, and for the use of the conception of probability.

VIII. THE CANONICAL FORM OF SCIENTIFIC THEORIES

All the foregoing instances may appear to you merely to suggest that, in dealing with mechanisms too complicated to be the object of a direct computation, our ignorance may force us to make use of statistical modes of computation. These statistical methods, you may say, are convenient devices whereby we neutralize, for certain special purposes, the defects of our mechanical knowledge.

If the insurance actuaries—so you may say—could use a sufficient knowledge of the world's mechanism, they would compute the precise time when each individual man is to die, just as the astronomers compute the eclipses. An almanac of mortality would take the place of the present nautical almanac. Everybody's funeral would be announced, if that were convenient, years in advance; and life insurance would appear to be a blundering and awkward substitute for scientific prediction. Because and only because, as a fact, no knowledge of the differential equations of the precise movements of matter, and no exact measurements of the accelerations or of the other rates of change in these movements gives us the power to predict the phenomena of nature in their detail, including the movements which determine life and death, we are obliged to substitute a statistical definition of the probable tendencies of a definable proportion of great numbers of men to die, in a way which varies with their numbers and their ages, for the precise knowledge of the hour of each man's death which we should all regard as a scientific ideal, if we could know the mechanism of life and death. The statistical view is a mere substitute for a mechanical view which our ignorance makes us unable to use, in the individual case, with sufficient accuracy. Such may be your comment.

The nautical almanac (so you may say) is the model of what applied science ought to to be. The mortality table is the convenient summary due to a necessary scientific evil. It is a device for recording our ignorance of the details of the world's mechanism along with our imperfect knowledge of certain probable and approximate tendencies to which the averages of many human lives are subject.

In other words, you may be disposed to insist: "Mechanical theories are the canonical forms towards which a growing scientific knowledge guides our way. Computations of individual events in terms of invariant laws whose validity is independent of time, are the models of what our scientific ideals seek. The statistical view of very complex mechanisms is an asylum in which our ignorance, perforce, has to find its refuge whenever, as in case of the swarms of molecules and the labyrinthine complications of organisms, the mechanical view of nature, as applied by us, loses its way."

In answer to this very natural comment, I am next led to say that, whether the natural world is a mechanism or not, the statistical view of nature would be, and so far as we know the facts is, applicable to sufficiently complicated systems of things and events, not as a mere substitute for these more exact computations which our ignorance of mechanical laws makes necessary, but as an expression of a very positive, although only probable and approximate, knowledge whose type all of the organic and social sciences, as well as most aspects of the inorganic sciences, illustrate. There is therefore good reason to say that not the mechanical but the statistical form is the canonical form of scientific theory, and that if we knew the natural world millions of times more widely and minutely than we do, the mortality tables and the computations based upon a knowledge of averages would express our scientific knowledge about individual events much better than the nautical almanac would do. For our mechanical theories are in their essence too exact for precise verification. They are verifiable only approximately. Hence, since they demand precise verification, we never know them to be literally true.

But statistical theories, just because they are deliberate approximations, are often as verifiable as their own logical structure permits. They often can be known to be literally, although only approximately, true.

This assertion is, in its very nature, a logical assertion. It is not any result of any special science, or of any one group of sciences. It solves no one problem about vitalism. It is a general comment on the value of the statistical point of view.

But, if the assertion is true, it tends to relieve us from a certain unnecessary reverence for the mechanical form of scientific theory—a reverence whose motives are neither rationally nor empirically well founded. It is the merit of Charles Peirce to have emphasized these logical considerations. Their importance for the study of scientific methods has grown greater with every year since 1891, when he began the publication of his remarkable papers in the *Monist,* entitled: "The Architecture of Theories," "The Doctrine of Necessity Examined" and "The Law of Mind." These papers are fragmentary; and yet in their way they are classical statements of the limitations of the mechanical view of nature, and of the significance of the statistical view of nature.

As I close, let me merely outline some aspects of Peirce's extension of the statistical view of nature beyond the range which Maxwell's and Boltzmann's study of the theory of gases directly exemplified.

IX. APPLICATIONS OF THE STATISTICAL VIEW TO THEORIES OF NON-MECHANICAL SYSTEMS. AGGREGATION AND ASSIMILATION AS STATISTICAL TENDENCIES

It at first seems, I have said, as if the statistical methods of the kinetic theory were applicable only to mechanisms whose complications were too vast to make it possible to follow in individual detail their necessary sequences of movements.

But this seeming is unfounded. Let me summarize in my own words a few considerations which Peirce summarily states, and which, to my mind, get a constantly increasing importance as the statistical view of nature comes to be applied to wider and wider fields of research.

Suppose an aggregate of natural objects which contains a very great number of members, each one of which is subject to some more or less exhaustively definable range of possible variations. These objects may be things or events, at your pleasure. They may be molecules or stars or cells or multicellular organisms or members of a society or observations of a physical quantity or proposals of marriage or homicides or literary compositions or moral agents or whatever else you will. The essential basis which is needed for a statistical view of such an aggregate is this:

First, the members of each aggregate must actually form a collection which is, for some physical or moral reason, a genuine and therefore in some way a definable whole.

Next, some more or less systematic tendency towards a mutual assimilation of the fortunes, the characters or the mutual relations of the members of this aggregate must exist. This tendency toward mutual assimilation may be of very various sorts.

The policyholders of an insurance company tend to assimilate the fortunes of their various investments when they all of them pay their premiums to the same company. The stars tend to a certain assimilation of the mutual relations amongst those photographs of their various spectra which chance to get collected on the photographic plates of the same astronomical observatory. For, as a consequence of this aggregation of photographs, the stellar spectra in question may tend to be classified; and the logical, as well as the other socially important, and the physical fortunes of objects which are once viewed or arranged or tabulated as objects belonging to the same class, tend, in general, to a further mutual assimilation.

Birds of a feather not only flock together, but tend to get statistically similar fortunes, when they come into chance contact with other birds or with breeders, with hunters or with biometrical statisticians.

All objectively well-founded classification is not only founded upon real similarities amongst the objects which belong to an aggregate, but tend to some increase of these similarities, in so far as these objects are not changeless mathematical entities, but are natural objects, whose fortunes are subject to change.

One of the most widely applicable laws of nature is, in fact, the law, wholly indefinable in mechanical terms, but always expressible in terms of statistical tendencies —the law that aggregation tends to result in some further and increasing mutual assimilation of the members of the aggregate. This assimilation may express itself in the fact that one classification or aggregation leads both logically and physically to another and deeper and also wider aggregation.

If the stars are already physically classified into two distinct drifts, which move through each other in two different directions, and if the stars in question tend to

get the photographs of their spectra assembled in the same observatory, then the classes into which the photographs tend in the long run to be grouped also tend to be such that, at least for some one resulting classification or aggregation of the photographs, the photographs of the spectra of the stars of one of the star drifts are grouped together, not only in the ideas which the astronomers form, but in the physical arrangements towards which certain groups of photographs, of symbols and of statistical tables, persistently tend.

The principles here involved depend upon the sorts of assimilation which the radiant phenomena of light make possible. For a photograph is a physical expression of a certain tendency whereby the structure of a photographic plate tends to be assimilated to the molecular structure and state of a radiating object—say a star. When the photographs of stellar spectra are grouped in classes, a secondary assimilation tends to take place, since similar spectra tend to get either placed or tabulated in similar ways. When this secondary assimilation of the photographs leads to an indirect discovery of the existence of the two star drifts themselves, a tertiary assimilation of the fortunes of those stars whose proper motions are sufficiently similar takes place, and tends to get represented in the knowledge of different astronomers.

The ideas of these various astronomers tend to further assimilation through the means used in scientific communication. The radiation of scientific knowledge continues the natural process which the radiation of light and the making of photographs of stellar spectra have already illustrated, and the rule continues to be illustrated that mutual assimilation is one aspect of classification and aggregation, and is a cumulative statistical tendency which accompanies them both.

The insurance companies and the transformation of modern civilization through the extension and aggregation of modes and devices whereby insurance is accomplished, furnish numerous other examples of this law of the fecundity of aggregation. The law, as I have said, holds in general for non-mechanical systems, although, as stellar evolution seems to indicate, it can also hold for mechanical systems. It may hold, in fact, for all natural processes which involve evolution.

Clerk Maxwell himself believed that the sharp distinctions which separate the different classes of elementary atoms, and the different types of molecular structure which determine the spectra of the molecules of different elements, are signs that no kinetic theory of the evolution of the chemical elements would ever be possible. It is precisely here that the latest advances, on the still so imperfectly defined outlying boundaries of physical and of chemical research, give a new significance to the statistical view of nature, by showing that if we take account of sufficiently large aggregates of things and of events, a kinetic theory of the evolution of chemical elements becomes a possibility worthy of future investigation, and certain to receive, in connection with the phenomena of radioactivity, further investigation upon statistical lines, whatever be the further fortunes of the mechanical view of nature, or of this problem about the evolution of the elements.

Of such speculations one can say that, if ever a theory of the evolution of the chemical elements becomes feasible, it will be, in part at least, a statistical theory, and will illustrate in new ways how widespread in material nature is the tendency to that mutual assimilation which all the phenomena of radiant energy illustrate, and of which the relatively uniform constitution and distribution of each one of the various chem-

ical elements through vast ranges of the physical universe may well be the result.

In brief, the evolution of stars, of elements, of social orders, of minds and of moral processes, apparently illustrates the statistical fecundity of nature's principal tendency—the tendency to that mutual assimilation which both defines aggregates, that is, real classes of natural objects, and tends to keep these classes or aggregates permanent in the world and to increase both their wealth of constitution and their extent.

Now it is this principle of the fecundity of aggregation which seems to be the natural expression, in statistical terms, for the tendency of nature towards what seems to be a sort of unconscious teleology—towards a purposiveness whose precise outcome no finite being seems precisely to intend. It is a statistically definable rule that changeable aggregates, when they are real at all, result from likenesses which their very existence tends both to increase and to diversify. The social fecundity of the principle of insurance illustrates this natural tendency. That marvelous result of the aggregation of scientific observers, of tabulations and of photographs, of the radiant phenomena which make the stars visible and of the microscopic phenomena and the logical interests which make probability definable—that marvelous result of these various aggregations which constitutes the whole procedure and outcome of modern inductive science itself, is an expression of this same general tendency—apparently the most vital and the most vitalizing tendency both of the physical and of the spiritual world—the tendency of aggregation and of classification to be fruitful both of new aggregations and of the orderly array of natural classes and of natural laws.

In the purely logical and mathematical worlds this tendency can get, and does get, precise description in terms of the pure logic of number and of order. In the physical world, in the world of time and of change, this principle gets further expressed as a statistical rather than a mechanical law—the law that classes, aggregations and organizations tend towards a definable sort of evolution.

As Charles Peirce pointed out, you need not suppose the real world to be mechanical in order to define and to conceive this sort of evolution. You need only suppose (1) the presence of the just-mentioned tendency to form aggregates, and to the mutual assimilation of the various parts of nature; (2) the statistically definable tendency to some sort of sorting or selection of the probable results to which any definable average constitution of the natural world at any moment leads; and (3) a tendency —and once more, a statistical and non-mechanical tendency, towards a formation of habits, and towards a repetition of such types of movement as have once appeared. Suppose these three tendencies (aggregation, selection and habit—and the statistical method shows these three to be widespread in the physical world); suppose these three, and you can define a process of evolution, never mechanical and never merely expressive of any previously settled designs, either of gods or of men. This process of evolution will then lead from mere chance towards the similation of mechanism, from disorderly to a more orderly arrangement, not only of things and of individual events, but of the statistically definable laws of nature; that is, of the habits which nature gathers as she matures. The philosophy of nature which will result will show how nature may well tend to appear in certain aspects more and more teleological, and to manifest what Greek vitalism found in nature. Whether the whole world is ultimately and consciously teleological or not, this view of nature would of course be unable to decide. But it would lay stress upon

the thought that what is indeed most vital about the world is that which also characterizes the highest life of the spirit, namely, the fecundity of whatever unites either electrons or souls or stars into streams or into other aggregations that, amid all chances, illustrate some tendency to orderly cooperation.

If this view of nature has any foundation, gentlemen, then, as the whole progress of inductive science illustrates, the way to further such scientific evolution is to get together, and to leave the rest to the statistically definable tendencies of nature. These are tendencies away from the chance distributions which the bell-shaped curve of random distribution illustrates, towards the orderliness of which the mechanical view of nature gives us one illustration, and by no means the most probably true illustration.

I should suppose, then, that whatever notes you may compare in these meetings, you will probably frequently and variously illustrate the statistical view of nature. This view is ill understood by those who think only how dry statistical tables and averages may seem. Mechanism is rigid, but probably never exactly realized in nature. But life, although it has its history, has also its statistics. And averages cease to be dry when they are averages that express the unities and the mutual assimilations in which the common ideals and interests, the common hopes and destinies of the men, of the social orders, of the deeds—yes, and perhaps of the stars and of all the spiritual world are bound up and are expressed.

Do you wish to experiment upon some new processes of social aggregation, of mutual assimilation, and of the study of photographs of your various spiritual spectra?

This practical question is for you to consider.

Josiah Royce
Harvard University

The National Academy of Sciences

The annual meeting of the Academy will be held in Washington on April 21, 22 and 23, 1914. Following is the tentative program:

Monday evening, April 20

7:30 P.M.—Meeting of the council in the private dining-room of the Cosmos Club.

Tuesday, April 21

10:00 A.M.—Business meeting of the Academy in the Oak Room of the Hotel Raleigh.

1:30 P.M.—Luncheon in the private dining-room of the Hotel Raleigh. (In the event of unfinished business, an adjourned business session may be held in the Oak Room following the luncheon.)

4:00 P.M.—Auditorium, National Museum. Inauguration of the William Ellery Hale Lectures by Sir Ernest Rutherford, of the University of Manchester. (Open to the public.) Subject: "The Constitution of Matter and the Evolution of the Elements." (Illustrated.)

9:30 P.M.—Reception to the members of the Academy and their guests, at the home of Alexander Graham Bell.

Wednesday, April 22

10:00 A.M.—Auditorium, National Museum. Public scientific session for the reading of papers.

1:00 P.M.—Luncheon in the Oak Room of the Hotel Raleigh.

2:30 P.M.—Auditorium, National Museum. Public scientific session for the reading of papers.

8:00 P.M.—Annual dinner of the members of the Academy and their guests in the Oak Room of the Hotel Raleigh.

At the annual dinner of the Academy will occur the first presentation of the medal for "Eminence in the Application of Science to the Public Welfare" to George Washington Goethals and William Crawford Gorgas for distinguished service in building the Panama Canal. (Presentation private.)

Thursday, April 23

10:00 A.M.—Oak Room, Hotel Raleigh. Business meeting of the Academy for the election

of members, foreign associates and two members of the council.

1:30 P.M.—Luncheon in the private dining-room of the Hotel Raleigh.

4:00 P.M.—Auditorium, National Museum. Second of the William Ellery Hale Lectures, by Sir Ernest Rutherford, of Manchester. (Open to the public.) Subject: "The Constitution of Matter and the Evolution of the Elements." (Illustrated.)

The chairmen of the various trust funds are requested to present at the meeting detailed written reports in accordance with instructions in rule 22, adopted at the annual meeting in 1911, which reads as follows:

The annual reports of the Committees on Research Funds shall, so far as the Academy has authority to determine their form, give a current number to each award, stating the name, position and address of the recipient, the subject of research for which the award is made, and the sum awarded; and in later annual reports the status of the work accomplished under each award previously made shall be announced, until the research is completed, when announcement of its completion and, if published, the title and place of publication shall be stated, and the record of the award shall be reported as closed.

At the scientific sessions of the academy, held in the Auditorium of the National Museum on April 22, papers will be presented as follows:

Pre-Cambrian Algonkian Algæ: CHARLES D. WALCOTT. (Lantern slides.)

Hewettite, Metahewettite and Pascoite, Hydrous Calcium Vanadates: W. F. HILLEBRAND, N. E. MERWIN AND FRED E. WRIGHT.

Two apparently different calcium vanadates are described, which resemble each other very closely and have the same composition—$CaO.3V_2O_5.9H_2O$—when holding their maximum water content at room temperature. One of them—hewettite—occurs at Minasragra, Peru, and has been noticed on a single specimen from Paradox Valley, Colorado. The other—metahewettite—occurs at numerous localities in western Colorado and eastern Utah. Both minerals are sparingly soluble in water. A third calcium vanadate—pascoite ($2CaO.3V_2O_5.11\frac{1}{2}H_2O$)— is also described. This occurs with hewettite at Minasragra. It is very soluble in water. The first and second minerals are regarded as hydrated acid hexavanadates—$CaH_2V_6O_{17}.8H_2O$—the third as a normal hexavanadate, $Ca_2V_6O_{17}.11\frac{1}{2}H_2O$.

The reasons for specific separation of hewettite and metahewettite are set forth in detail. All three minerals are so sensitive to changes in atmospheric humidity that their water content varies within wide limits at different times of the year. The removal of all or nearly all the water does not result in breaking down of the crystal structure, and until this has occurred the water is wholly or in great part taken up again when opportunity is offered.

The importance is emphasized of bringing all minerals that behave in this way to a definite maximum water content before analyzing them and of following carefully the course of dehydration under prescribed conditions. Detailed directions are given for such tests and for avoiding several sources of error. Attention is also called to two fairly constant associates of metahewettite. One of these (also a constituent of carnotite ores) is a gray hydrous silicate of aluminum, trivalent vanadium and potassium. The other is elemental selenium, the existence of which as a mineral species seems now for the first time established.

The Origin of Monocotyledony: JOHN M. COULTER.

The evidence of vascular anatomy, supported by the historical record, as well as by general morphological considerations, has demonstrated that the Monocotyledons have been derived from the Dicotyledons. It remained to obtain evidence of the transition from dicotyledony to monocotyledony. The two opposing views, each supported by considerable indirect evidence, are (1) that the monocotyledonous condition has arisen by a fusion of the two cotyledons, and (2) that it has arisen by a suppression of one of them.

Material of *Agapanthus umbellatus* (Liliaceæ) obtained from South Africa proved to be occasionally dicotyledonous, so that it was possible to determine the relation between the two conditions. The result has shown that neither one of the theories advanced to explain the origin of monocotyledony is tenable, but that this condition arises from the continuation of one growing point on the cotyledonary ring rather than a differentiation of two growing points. In every case, the cotyledonary apparatus begins as a ring, and continues its growth as one cotyledon or two. It is evident that there is neither suppression of one cotyledon nor fusion of two.

Heredity of Some Emotional Traits: CHARLES B. DAVENPORT.

Among emotional traits, violent temper and un-

controllable eroticism have an hereditary behavior that indicates that they are each due to a single positive determiner which may be regarded as interfering with the inhibitory mechanism. With a slightly less certainty marked cases of "Wanderlust" appear to be inherited as if sex-linked. Illustrated by diagrams and lantern slides.

The Causes of the Clotting of Blood: W. H. Howell.

In circulating blood or lymph a small amount of prothrombin is contained in solution in the plasma. This prothrombin is prevented from reacting with the calcium to form thrombin by the presence of an adequate amount of antithrombin, or, if any thrombin is formed, its coagulating effect on fibrinogen is prevented by the antithrombin. The normal fluidity of the circulating blood is dependent, therefore, upon the presence and action of the antithrombin. In blood-platelets and in leucocytes there is contained a supply of thromboplastic material (phosphatid-compound) and also of prothrombin. On the shedding of blood the disintegration of the platelets and, to a lesser extent, of the leucocytes liberates thromboplastin and prothrombin. The former neutralizes the antithrombin, the latter, together with the prothrombin already present in the plasma, is changed to thrombin by the action of the calcium. Cell-free plasmas may be clotted by the addition of thromboplastin (kephalin) to neutralize the antithrombin.

The Luminescence of Kunzite: Edward L. Nichols and Horace Leonard Howes.

The Prompt Distribution of Convulsants in Cardiectomized Frogs deprived of their Lymph Hearts: S. J. Meltzer.

Several years ago the writer reported that in frogs from which the heart was removed, an injection of strychnin, morphin or acid fuchsin brought on convulsions. For the two latter substances the effect was more prompt and rapid than in animals with normal circulation. The conclusions seemed to be inevitable that the distribution of these substances must take place by some mechanism other than the circulatory apparatus. Two years ago J. J. Abel stated that the success of the experiment depends upon the normal activity of the two anterior lymph hearts; when these are destroyed no convulsions can take place. In recent experiments carried out by Githens, of the Rockefeller Institute, Dr. Joseph, of the University of St. Louis, and by myself in a long series of experiments the lymph hearts were destroyed and after a day or two, when the animals recovered, the heart was removed and the substances injected. The result was as prompt as if the lymph hearts were intact. Furthermore the injections were made this time into the lymph sacs of the thigh and the substances therefore had to travel long distances. Apparently a quite efficient distribution may take place through the connected lymph spaces without the aid of any part of the circulatory apparatus.

Contributions to the Geology of Bermuda: L. V. Pirsson and T. Wayland Vaughan.

Recently a deep well, about 1,400 feet deep, has been bored in Bermuda Island. The samples taken from this well at regular intervals show that there is first penetrated a considerable depth of lime deposits produced by organic life, then follows, down to about 600 feet, brownish weathered igneous rock, after which black unoxidized lavas and igneous material persist to the bottom. The lime deposits contain the remains of organisms. The facts disclosed have important bearings on the origin and geological history of the island and on the problem of coral reef formations. The igneous geology is discussed by L. V. Pirsson and the later history and coral reef problem by Dr. Vaughan.

The lectures founded in memory of the late William Ellery Hale, of Chicago, will be inaugurated by Sir Ernest Rutherford, of the University of Manchester, who will speak in the Auditorium of the National Museum, Washington, D. C., on April 21 and 23, 1914, at 4 P.M.

The committee in charge has planned a series of such lectures covering several years on the general subject of evolution, which is designed to give a clear and comprehensive outline of the broad features of inorganic and organic evolution in the light of recent research. Sir Ernest Rutherford's lectures will deal with the Constitution of Matter and the Evolution of the Elements. Aided by many illustrations, including some of the experiments which brought to him the award of the Nobel Prize, Sir Ernest will explain how the discovery of radio-activity and the study of the electron have revolutionized our views on the nature of matter. By these new means of investigation, the chemical elements and the complex compounds which they unite to form may be shown to consist of units of positive and negative electricity. Moreover, all nega-

tive electrons are precisely alike, from whatever form of matter they may be derived. Thus we are prepared to witness some of the transformations of the chemical elements, such as the spontaneous disintegration of radium and the production of helium from it.

These addresses on the fundamental structure of matter will prepare the way for succeeding lectures, which will deal with the various transformations of matter involved in the evolution of the earth and its inhabitants.

The second course in the Evolution Series will be given at the next autumn meeting of the Academy by Dr. William Wallace Campbell, director of the Lick Observatory, Mount Hamilton, California. Provided with his raw material, as it were, by Sir Ernest Rutherford, Dr. Campbell will sketch the various types of bodies which make up the universe, describe their connection in systems, and explain the principal theories of stellar evolution. His object will be to show how stars and stellar systems are gradually evolved from an earlier state and to afford a view of the earth in its first phases of development. In this way the intimate relationship of the earth with the moon and the other bodies of the solar system will be made apparent, as well as the continuity of the process which connects the present with the remote past. Dr. Campbell will introduce some of the results of his extensive researches with the powerful instruments of the Lick Observatory and will employ a large collection of astronomical photographs for illustration purposes.

A distinguished European geologist will be invited to give the third course of lectures at the annual meeting of the Academy in 1915. Taking the earth from the hands of the astronomer, he will show how its surface features have been altered in the process of time. Later lectures, preserving the continuity of the series, will then enter the field of organic evolution and illustrate the bearing of recent investigations in paleontology, zoology and botany on the evolution of plant and animal life. The evolution of man will form the subject of a subsequent course, and the series will close with an account of the rise of the earliest civilizations, coming into touch with modern times in the life of the Nile Valley.

In all cases the lectures will be given by leading European and American investigators, whose personal researches have contributed largely toward the development of the fields of science which they represent. Every effort will be made to secure continuity and homogeneity of treatment, in order that the published lectures may unite into an adequate and well-balanced description of evolution in the broadest sense. The lecturers chosen will be able to eliminate unessential technicalities and to present their subjects clearly and intelligibly to general audiences. The series on Evolution should therefore appeal to a large public, interested in the broader aspects of science, but not necessarily familiar with its special methods or technical details.

The lectures will be open to the public without charge, and a cordial invitation is extended to all who may wish to attend them.

ARTHUR L. DAY,
Home Secretary
SMITHSONIAN INSTITUTION,
WASHINGTON, D. C.

THE AMERICAN PHYSICAL SOCIETY

A REGULAR meeting of the Physical Society will be held at the Bureau of Standards, Washington, on April 24 and 25. Morning sessions will begin at 9:30.

Attention is directed to the following special features of the coming meeting:

1. The members of the Physical Society are invited by the National Academy of Sciences to attend the William Ellery Hale lectures by Sir Ernest Rutherford, F.R.S., upon "The Constitution of Matter and the Evolution of the Elements" (illustrated). The lectures are two in number, and are delivered in the auditorium of the National Museum on April 21, and April 23, at 4:00 P. M.

2. A special attraction will be the exhibit of apparatus arranged by a local committee of the Physical Society. Thus far entries have been received from more than thirty manufacturers, importers and industrial research estab-

lishments. University laboratories and federal scientific bureaus will be well represented, so that an eminently successful exhibit is assured.

3. A lecture by Sir Ernest Rutherford will be given Friday afternoon at 3:30, "On X-ray and Gamma-ray Spectra" (at the Bureau of Standards?).

4. The three sessions of the meeting for the reading of papers will be joint sessions with the Electrophysics section of the American Institute of Electrical Engineers. (The morning sessions will be in charge of the Physical Society and the Friday evening session in charge of the A. I. E. E.)

5. Another feature will be the opening of the newly-completed electrical building of the Bureau of Standards. The apparatus exhibit will be there installed.

6. Members of the Physical Society and others in attendance will be guests of the scientific staff of the Bureau of Standards at luncheon in the west laboratory, at 1:00 P. M., on the days of the meeting.

7. Saturday afternoon there will be an opportunity to visit points of interest in the city, under the guidance of local members of the A. I. E. E. It is possible also that another session will be provided for the reading of papers, in view of the unusual number of titles presented.

A. D. Cole,
Secretary

THE AMERICAN JOURNAL OF BOTANY

At the Atlanta meeting of the Botanical Society of America, in January, 1914, plans were perfected for the publication of a new journal, known as the *American Journal of Botany*. As stated in the introductory note to No. 1, the need of increased facilities for the prompt publication of the results of botanical investigation has been keenly felt for some time, and the promptness with which this new opportunity has been taken advantage of, as indicated by the receipt of copy for the new venture, shows that the establishment of a new publication is amply justified.

An agreement has been entered into between the Botanical Society of America and the Brooklyn Botanic Garden for cooperation in the publication of this *Journal*. By the terms of this agreement, which has been entered into for a period of three years, financial responsibility is assumed jointly by the Botanical Society of America and the Brooklyn Botanic Garden. The Garden names the business manager and one member of the editorial board, and the Botanical Society of America elects the editor-in-chief and four other members of the editorial board.

The *Journal* is the official publication of the Botanical Society of America, and business offices are maintained at the Brooklyn Botanic Garden and at 41 North Queen Street, Lancaster, Pa.

It is the plan for the present to include contributions to all branches of botanical science, and longer papers will be especially welcome. It is not the present plan to include reviews of literature. Each issue will consist of about fifty pages, and contributions will be welcome from all botanists. There will be ten numbers to a volume.

All correspondence with reference to prospectus, subscriptions, advertisements, and exchanges with other publications, should be addressed to American Journal of Botany, Brooklyn Botanic Garden, Brooklyn, N. Y., and correspondence concerning editorial matters and all manuscript submitted for publication should be addressed to the editor-in-chief, Professor F. C. Newcombe, Geddes Heights, Ann Arbor, Michigan. The other members of the editorial board for 1914 are C. Stuart Gager, business manager, Brooklyn Botanic Garden; Robert A. Harper, Columbia University; Duncan S. Johnson, Johns Hopkins University; L. R. Jones, University of Wisconsin; George T. Moore, Missouri Botanical Garden; and Edgar W. Oliver, Brooklyn Botanic Garden.

THE CANADIAN ENTOMOLOGICAL SERVICE

Thirty years ago, in 1884, the Canadian government appointed a Dominion entomologist to advise agriculturists and others regarding the control of insect pests. Two years

later on the establishment of the experimental farms system, Dr. James Fletcher, who occupied the position, was attached to the new branch of the Department of Agriculture in the joint capacity of entomologist and botanist, which position he occupied with conspicuous success until his death in 1908. The growth in importance of the subjects necessitated their separation and accordingly divisions of entomology and botany were created. Dr. C. Gordon Hewitt was appointed Dominion entomologist in 1909 and entrusted with the work of organizing the new division of entomology of the experimental farms branch of the Department of Agriculture, with offices and laboratory at the Central Experimental Farm, Ottawa.

The urgent need of legislation in order to permit action to be taken to prevent the introduction into Canada and spread within the country of serious insect pests and plant disease was responsible for the passage of the Destructive Insect and Pest Act in 1910. The still greater need of investigations on the insect pests affecting agriculture, forestry and other branches of human activity has led to the establishment of field or regional laboratories in different parts of Canada with trained entomologists in charge to study local problems.

Owing to the consequent expansion of the entomological work along investigatory and administrative lines and the fact that such work did not constitute a necessary part of the work of the experimental farms system and executively was virtually distinct, the entomological service has now been separated from the experimental farms branch and has been constituted an independent branch of the Department of Agriculture under the direction of the Dominion entomologist. It is proposed to erect a building to provide offices and laboratories for the new entomological branch. Will correspondents kindly note that all official communications and publications should be addressed to "The Dominion Entomologist, Department of Agriculture, Ottawa."

This reorganization, which will also include the establishment of a national collection of the insects of Canada in the Canadian National Museum (The Victoria Memorial Museum) at Ottawa under the care of the Dominion entomologist, marks an important step in Canadian entomology. It will result in a still greater development of the study of Canadian insects along scientific and practical lines.

SCIENTIFIC NOTES AND NEWS

AT the meeting of the American Philosophical Society to be held at Philadelphia on April 23, 24 and 25, a large and important program of scientific papers will be presented. An account of the meeting with abstracts of the papers will be published in SCIENCE.

MR. F. W. HODGE, of the Bureau of American Ethnology, has been elected an honorary member of the Sociedad Científica Antonio Alzate of the City of Mexico.

PROFESSOR LAWRENCE MARTIN, of the University of Wisconsin, has been elected a corresponding member of the Kaiserlich-Königliche Geographische Gesellschaft in Vienna.

THE Austrian Zoological and Botanical Society has awarded the Archduke Rainer gold medals to two members of Yale University, Dr. Ross G. Harrison, Bronson professor of comparative anatomy, and Dr. George R. Wieland, lecturer in paleobotany.

THE British Local Government Board has authorized the following special researches, to be paid for out of the annual grant in aid of scientific investigations concerning the causes and processes of disease:

1. An investigation by Dr. Eardley Holland into the causes of stillbirths.
2. A continuation of the Board's inquiry into the cellular contents of milk by Professor Sims Woodhead.
3. A continuation of the Board's inquiry into the causes of premature arterial degeneration by Dr. F. W. Andrewes.
4. An investigation by Dr. M. H. Gordon and Dr. A. E. Gow into the etiology of epidemic diarrhœa in children.

THE council of the Royal Geographical Society has decided to award their royal medals and other honors for the present year as fol-

lows: Founder's medal, Professor Albrecht Penck, professor of geography at Berlin and director of the Oceanographical Institute; Patron's medal, Dr. Hamilton Rice, of Boston, Mass., known for his explorations of the region of South America drained by the headwaters of the Orinoco and of the northern branches of the Amazon; Murchison grant, Commander H. L. L. Pennell, R.N., a member of the Antarctic expedition of 1910, and selected by Captain Scott to command the *Terra Nova* after the landing of the shore parties; Gill memorial, Mr. A. E. R. Wollaston, who has made extensive journeys in many parts of the world, chiefly for zoological work; Cuthbert Peck grant, Dr. J. Ball, employed in the geological survey of Egypt for the past eighteen years; Back grant, Mr. J. N. Dracopouli, known for his work in the Sonora desert of Mexico and for his expedition to the Lorian Swamp.

The former students of Dr. J. McKeen Cattell, professor of psychology in Columbia University, at a dinner held in New York on April 8, presented him, in celebration of his completion of twenty-five years as professor of psychology, with a "Festschrift" in the form of reviews of his researches and of work in psychology to which they have led. The contents of the volume are:

"Work on Reaction Time," by V. A. C. Henmon.

"Studies of Reading and Perception," by Walter F. Dearborn.

"The Association Method," by F. Lyman Wells.

"Psychophysical Contributions," by R. S. Woodworth.

"Studies by the Method of Relative Position," by H. L. Hollingworth.

"The Study of Individual Differences," by E. L. Thorndike.

On April 6, 7 and 8, there was held at Columbia University a Conference on Individual Psychology by former students of the department of psychology, at which thirty papers were presented.

Dr. M. Miyoshi, professor of botany in the Imperial University of Tokyo, is visiting the scientific institutions of the United States.

Princeton University has granted leaves of absence for the academic year 1914–15 to Professor H. D. Thompson, of the department of mathematics; and to Philip E. Robinson, assistant professor of the department of physics.

The American Association of Pathologists and Bacteriologists met in Toronto, on April 10 and 11, under the presidency of Professor J. J. McKenzie, of Toronto University. There also met at Toronto the International Association of Medical Museums, with Professor R. M. Pearce, of Philadelphia, as president, and the American Association for Cancer Research, under the presidency of Dr. Ernest E. Tyzzer, of the Harvard Medical School.

Mr. F. J. North, assistant in the geological laboratory, King's College, London, has been appointed assistant keeper in the department of geology in the National Museum of Wales.

Professor M. Fréchet, of the University of Poitiers, will give at the University of Illinois during the academic year 1914–15 a course of lectures on general analysis.

Indiana University will hold, on April 16 and 17, a conference on educational measurements. The principal speaker is Professor E. L. Thorndike, of Teachers College, Columbia University.

Dr. John A. Brashear, of Pittsburgh, recently delivered two illustrated lectures at the University of Illinois on "The Contribution of Photography to our Knowledge of the Stellar Universe," and "Engineering Problems in the Construction of Large Telescopes." The lecture on celestial photography was held in the university auditorium with an audience of fifteen hundred persons.

Dr. L. A. Bauer gave on April 3, in the Engineering Societies Building, the evening lecture at the first joint meeting of the American Geographical Society and of the Association of American Geographers, his subject being "The General Magnetic Survey of the Earth," illustrated by lantern slides of the work of the *Carnegie*, and of the various expeditions to more or less unexplored countries.

THE annual John Lewis Russell lecture of the Massachusetts Horticultural Society was delivered on March 21, by Dr. Perley Spaulding, pathological inspector of the Horticultural Board of the U. S. Department of Agriculture. The subject was "Undesirable Foreign Plant Diseases."

DR. M. W. TWITCHELL, the assistant geologist of New Jersey, lectured before the department of geology of Princeton University on March 16, 20, 23, 27 and 30, the general subject of the series being "The Geology of New Jersey."

PROFESSOR GEORGE GRANT MACCURDY, of Yale University, gave two lectures at Rutgers College on March 25 and 26, one before the New Jersey State Microscopical Society on "Primeval Man," the other before the Phi Beta Kappa Society on "The Dawn of Art."

PROFESSOR SAMUEL W. WILLISTON addressed the Chicago chapter of the Sigma Xi at its regular winter quarter meeting, on March 11, on the topic: "Recent Discoveries Relative to the Early Land Life of North America."

ON March 28, Professor C. H. Shattuck, of the Forestry Department of the University of Idaho, delivered a lecture before the Puget Sound Branch of the American Chemical Society on "Wood Processing."

DR. ALEXANDER F. CHAMBERLAIN, professor of anthropology at Clark University, died on April 8, at the age of forty-eight years.

DR. JOSEPH D. BRYANT, professor of surgery in the University and Bellevue Hospital Medical College, died in New York on April 8, aged sixty-nine years.

DR. ALFRED CONOR, vice director of the Pasteur Institute at Tunis, has died from infection contracted in his experimental work.

THE U. S. Civil Service Commission announces an examination for mining engineer in the Bureau of Mines, Department of the Interior, for service in the field, in relation to coal mining or metal mining, at salaries ranging from $2,400 to $4,000 a year. For the same bureau there will be held examinations for mine statistician and for assistant-engineer of mine tests at Pittsburgh at salaries ranging from $1,800 to $2,400.

MR. ANDREW CARNEGIE has given $100,000 to the New York Zoological Society to provide a pension fund for the New York Zoological Park and the Aquarium. The scientific staff and the employees will contribute annually 2 per cent. of their salaries, and any sum that may be lacking will be made up by the Zoological Society.

THE Rockefeller Institute for Medical Research, New York, announces that it has received from Mr. John D. Rockefeller an additional endowment of $1,000,000 for the purpose of organizing a department for the study of animal diseases. A gift of $50,000 has also been received from Mr. James J. Hill, for the study of hog cholera. The announcement says: "It is the expectation of the trustees of the institute that the new department by making possible a very thorough and exhaustive study of animal diseases by trained experts will prove a great boon to raisers of cattle, hogs, sheep, and other animals, as the opinion has been expressed that many of the diseases could be held in check and perhaps practically stamped out if the breeders had practical knowledge on which to act. With the present facilities at hand, the income from the $1,000,000 endowment will make it possible to carry on the work on a broad scope at once."

THE department of terrestrial magnetism of the Carnegie Institution of Washington, founded on April 1, 1904, is now occupying its new building, which has been especially erected, at 36th Street and Broad Branch Road, Washington, D. C., to provide the requisite facilities for the varied research work of the department, both along experimental and observational lines.

SIR ERNEST SHACKLETON has bought the ship *Polaris*, now at Sandefjord, to be his "flagship" on his forthcoming Antarctic expedition.

THE Swedish government has appropriated $13,500 for traveling expenses to be dis-

tributed among Swedish engineers who desire to visit the Panama-Pacific Exposition in San Francisco in 1915.

The fiftieth meeting of the New England Association of Chemistry Teachers will be held in Boston on Saturday, April 25, 1914. The morning session will be devoted to the past, present and future of the association. Past presidents will speak, and the history of the association will be read. A complimentary luncheon will follow. It is hoped that the afternoon session will include a moving picture exhibition of chemical industries. In the evening there will be a reception and collation, followed by speaking, at the Copley Plaza.

The twenty-fifth session of the Biological Laboratory of the Brooklyn Institute of Arts and Sciences, located at Cold Spring Harbor, Long Island, will be held from June to September. The regular class work will begin Wednesday, July first, and will continue for six weeks, to August 12. The instruction offered includes a course in field zoology by Dr. H. E. Walter, of Brown University, assisted by Dr. S. I. Kornhauser; in bird study by Mrs. H. E. Walter; in comparative anatomy by Professor H. S. Pratt, of Haverford, and Dr. D. D. Whitney, of Wesleyan University; in animal bionomics and evolution by Dr. C. B. Davenport; cryptogamic botany by Professor H. H. York, of Brown University, and Dr. W. E. Maneval; systematic and field botany by Professor John W. Harshberger, of the University of Pennsylvania. Opportunities are also offered for investigation in zoology and botany. A training course for field workers in eugenics is given under the direction of Dr. C. B. Davenport and Mr. H. H. Laughlin. The complete announcement may be got by addressing the Biological Laboratory, Cold Spring Harbor, N. Y.

There are now being assembled in the United States National Museum, the bones of a very small three-horned dinosaur which is being made the type of a new species. This diminutive dinosaur, when completely assembled, will measure about six feet in length and stand only about three feet high. Its head is twenty-two inches long. When its bones are compared with those of the larger members of this extraordinary family of reptiles, it will be seen that this specimen is less than one fourth of their size. In the National Museum are several skulls of one of the large horned dinosaurs, *Triceratops*, which measure from six to eight feet, and in one case, nine feet. The group to which this new member belongs is called the *Ceratopsia*, from the horns which adorn their heads; two above the eyes and one on the end of the nose. Unlike the others, this species has small and not prominent horns over the eyes, while the nasal horn is an outgrowth of the nasal bone and not an additional growth, as is the case with the others. Another peculiarity is that this horn is split lengthwise in such a manner that one side has the appearance of having slipped by the other. Its jaws are like those of a turtle, there being no front teeth but a sharp curved beak. Farther back in the jaws, however, are very finely sculptured cutting teeth, which show the animal to have been herbivorous. Like the other members of this group, it has a deep collar known as a frill, but in this species it has an open space on either side of the neck. The frill was covered with horn and formed a defensive armor for the protection of the neck. This particular specimen was found with the foot and tail articulated, which makes it especially interesting as being the first complete and connected specimen ever obtained. The foot has four toes, the first with two bones, the second with three, the fourth with five, while only a trace of the fifth toe remains, tending to show the loss of that member through disuse, as is the case with the horse. Parts of the other feet are also in this collection, as well as nearly all the bones of one individual. In the whole specimen there are but few bones and parts which will have to be restored. Considering that the first specimens of this family were discovered some forty years ago, it is curious that this small individual is the most complete one that has been found. These fossils were found by Mr. Charles W. Gilmore during the summer of 1913, while he was working for the Geological

Survey in the Blackfeet Reservation in northwestern Montana. The partial skeletons of five individuals were uncovered at the same time and form a most valuable addition to science. Mr. Gilmore has written a preliminary paper on the new species, published in the Smithsonian Miscellaneous Collections, and is working on the assembling of the specimen for exhibition in the National Museum.

CALIFORNIA state inspectors at San Francisco have found a new canker disease on chestnut trees recently imported from Japan. According to Dr. Haven Metcalf, the government's expert on such diseases, this appears to be of the same type as the chestnut blight which is ravaging the forests of the eastern United States, and it is possible that the new disease would be equally destructive if it became established in this country.

UNIVERSITY AND EDUCATIONAL NEWS

THE General Education Board has promised to give $750,000 to Wellesley on condition that the balance of the $2,000,000 restoration and endowment fund is completed by January 1, 1915.

IT is said that one million dollars will be received by the University of Pennsylvania from the estate of Dr. Louis A. Duhring, for many years professor of dermatology. At the time of his death on May 8, 1913, his bequest was estimated at only $400,000.

GRINNELL COLLEGE has completed its $500,000 endowment fund. Of this sum $100,000 was given by the General Education Board and the rest was raised by the college. The productive funds of the college now total more than $1,300,000. Of the amount just secured, $150,000 is to be devoted to the erection of new buildings.

THE managers of the Presbyterian Hospital, New York, have taken action reorganizing the administration of the scientific and therapeutic work at the hospital so as to provide for single responsibility for both the medical and the surgical services. Dr. Theodore C. Janeway, Bard professor of the practise of medicine in the College of Physicians and Surgeons, Columbia University, has been designated medical director of the hospital, and Dr. George E. Brewer, professor of surgery, has been designated surgical director. Dr. William G. MacCallum, professor of pathology, has been appointed pathologist at the Hospital.

PROFESSOR ALAN W. C. MENZIES, Ph.D., now head of the department of chemistry at Oberlin College, has been elected professor of chemistry at Princeton University. Other changes are Dr. Edward Gleason Spaulding, promoted to a full professorship in philosophy; and Dr. Thomas Hakon Gronwall, elected assistant professor and preceptor in mathematics.

RECENT promotions in the faculties of the University of Chicago include the following: To professorships: Harlan H. Barrows, geography; and Ernest J. Wilczynski, mathematics. To associate professorships: Elliot R. Downing, natural science (College of Education); Albert Johannsen, petrology; Walter S. Tower, geography. To assistant professorships: Storrs B. Barrett, Yerkes Observatory; Albert D. Brokaw, mineralogy and economic geology; Rollin T. Chamberlin, geology; and Arno B. Luckhardt, physiology. The new appointments include that of Oliver J. Lee to an instructorship in astronomy.

JAMES WITHYCOMBE has resigned his position as director of the Oregon Agricultural College Experiment Station.

DR. WILLIAM E. HOCKING, professor of philosophy in the University, has accepted a chair of philosophy in Harvard University.

MR. G. H. HARDY, M.A., fellow of Trinity College, University of Cambridge, has been appointed to be Cayley lecturer in mathematics, and Mr. A. Berry, M.A., fellow of King's College, a university lecturer in mathematics.

DISCUSSION AND CORRESPONDENCE

MINERAL NOMENCLATURE

THE need for revision of mineral nomenclature has been recently emphasized by Professor Austin F. Rogers, of Stanford University.[1] While I agree in the main with the

[1] *Proc. Amer. Phil. Soc.*, 52, 606–615, 1913.

views he expresses, it seems to me that his plan of treatment of isomorphous series is likely to complicate rather than simplify matters. Professor Rogers proposes that minerals be named by the predominant molecule of the isomorphous series, that isomorphous admixtures be indicated by adjectives, and that chemical prefixes be restricted to artificial substances. It would appear to me preferable to have mineral names apply to the isomorphous series as a whole, and, in most cases, to use chemical prefixes for end-members of series, whenever it is desired to discuss their relations.

The difference between these methods can best be brought out by citing a few examples. For instance, according to Rogers' plan the term carnotite would apply only to a (theoretical) potassium end-member of the isomorphous series of double uranyl vanadates, tyuyamunite to the calcium end-member. Specimens in which both are present would have to be called calciferous carnotite, if potassium predominated, and kaliferous tyuyamunite if calcium predominated, and indeed an analysis would be necessary before the material could be correctly named at all. According to my plan the name carnotite would apply to the isomorphous series itself, and could then continue to be used by laymen—miners, dealers, newspaper writers—to whom the exact composition is of no significance, to describe any sample of the mineral; while the compound names calcio- and kalio-carnotite would be used by the specialist discussing the composition of a given specimen, or its relations with other minerals.

The first plan would also do away with a number of well-known, useful, mineral names—with axinite, columbite and wolframite for instance, because they are made up of iron and manganese end-members—and, in general, with every name of a mineral as soon as it is discovered to be an isomorphous mixture. It would further require the introduction of two new names, for the end-members, in most cases. According to the second, on the other hand, advance of knowledge would not necessitate either the discarding of established names, nor the introduction of wholly distinct, independent, arbitrary ones, but only the addition of appropriate chemical prefixes, yielding ferro- and mangano-axinite, ferro- and mangano-columbite, etc. Some of these compound names have already been introduced, and have proved very useful in discussions of the relationships of the minerals; and they can cause no ambiguity so long as it is definitely understood that they apply to end-members of series only. Natronorthoclase in the sense of orthoclase containing sodium replacing part of the potassium, cobaltocalcite in that of calcite containing a little cobalt, etc., would, however, have to be dropped (as also recommended by Rogers).

In the few cases where the end-members of a series are common, well-known and well-characterized minerals, convenience may demand that independent names be retained as synonyms of these compound ones. Thus while wolframite remains the name for the isomorphous mixtures of iron and manganese tungstates, ferberite and hübnerite may at times be used instead of ferro- and mangano-wolframite, since they are sufficiently characteristic to be recognized by miners, dealers and beginning students. Yet I have found that practically every mineralogist, when asked what ferberite is, will reply "wolframite high in iron" rather than "iron tungstate." So, even if the distinct names are retained in this case the compound chemical ones had better be used synonymously with them.

My suggestions are then, in short, that when a mineral is discovered to be an isomorphous mixture of two (or more) components the species name shall be regarded as a group name, representing any and all members of the series; that the end-members in general shall be designated by chemical prefixes applied to the species name; but that if the end-members are so distinct, characteristic and well known that they can be thought of independently, and already have separate names, that these names be retained as synonyms of the compound, chemical, ones. If this plan should be systematically applied it would simplify mineral nomenclature with a minimum of

change from existing conditions, apparently a highly desirable result. EDGAR T. WHERRY
NATIONAL MUSEUM,
WASHINGTON, D. C.

THE WELLESLEY FIRE

TO THE EDITOR OF SCIENCE: The article of Professor Caroline B. Thompson entitled "The Wellesley Fire" stated that "the more important losses to physics are lantern slides, a collection of crystals, a unique collection of Nicol prisms. . . ." The lantern slides, although a useful adjunct to the apparatus, represented an inconsiderable part of the total loss. It is true that it will be difficult to duplicate the larger crystal sections and that the Nichol prisms, although by no means forming a "unique collection," were unusually good for a college of liberal arts as indeed was the entire equipment.

In a loss amounting in the aggregate to many thousands of dollars it is idle to enumerate particular items, but it may be noted that the department was especially fortunate in its equipment for the study of advanced optics and electricity. The apparatus included a commercial photometer, a large optical bench for the study of interference and diffraction effects, a Michelson interferometer, Lummer plate spectroscope, polariscopes, polarizing microscopes, Frick polarimeter, apparatus for the Zeeman effect, etc. Recently considerable time had been devoted to developing an experimental lecture course in "Electric Oscillations." To bring the equipment again to the same degree of efficiency will be the work of years. LOUISE SHERWOOD MCDOWELL
WELLESLEY COLLEGE

SCIENTIFIC BOOKS

Across Unknown South America. By HENRY SAVAGE-LANDOR. Two volumes. Boston, Little, Brown & Company. 1913. Pp. xxiii + 377 and xvi + 439, illustrated.

A map given at the end of the first volume shows that the author traveled extensively in various parts of South America, but it is not clear which part of that continent he regards as unknown. From Rio he went to S. Paulo, and thence to Araguary in western Minas by railway. From there to the city of Goyaz he traveled a much used road. From Goyaz he went westward on the road leading to Cuyabá. That road is not only much traveled and well known, but is shown on most maps of Brazil, such as Stieler's hand atlas and Baron Homem de Mello's atlases of Brazil, 1882 and 1909. There is even a telegraph line connecting the city of Goyaz with the city of Cuyabá. Francis de Castelnau made the trip in 1844, and his account of it is given in detail in the second volume of his "Expedition dans les parties centrales de l'Amérique du Sud," pages 218–282.

At Capim Branco, near Cuyabá, the author abandoned the main road and struck out across country by compass. The various disagreeable experiences off the main road were such as one would naturally expect, whether traveling in the interior of Brazil or in the interior of Pennsylvania. Little wonder that his men objected. This wandering about through the woods seems to have been regarded as exploration of an unknown region, though it is to be noted that he found farmers living there, and that the names of the streams were known to his companions.

After a few days in this "unknown" region he came out in the road leading from Rosario to Diamantino, and near the latter place took a canoe, without the necessary outfit, and descended the Arinos and Tapajos.

Here again he seems to regard the region as unknown. But the Arinos and Tapajos, in spite of their many and difficult falls and rapids, have been navigated constantly for more than a hundred and fifty years. Father Ayres de Cazal in his "Corografia Brazilica," published at Rio in 1817, says (Vol. I., p. 261) that in 1747 Captain João de Souza descended to Pará by way of Rios Arinos, Tapajos and Maranhão, and returned by way of the Madeira with canoes laden with European goods.

Dr. Mello Moraes in his "Corografia historica do Imperio do Brasil," Rio, 1859, 486, speaks of the voyage of João de Souza in 1747, but adds that Leonardo de Oliveira descended that river in August, 1742.

Joaquim Ferreira Moutinho, author of "Noticia sobre a provincia de Matto Grosso," S. Paulo, 1869, in speaking of the guaraná trade in Matto Grosso, says (p. 212) that the great consumption of this article keeps up the trips to Pará by way of the rivers Preto, Arinos, etc. This author speaks at length of the trips on the Arinos and Tapajos and gives the distances between the principal falls, and adds that the trip to Pará is made nowadays much more easily than formerly on account of the experience of the pilots and canoemen (p. 216).

Dr. Severiano da Fonseca in his "Viagem ao redor do Brasil," I., 75–79, tells of various trips up and down the Arinos and Tapajos, and gives the distances between various points.

In 1827 G. H. von Langsdorff, the well-known traveler, then Russian consul-general to Brazil, made a trip down the Arinos and Tapajos. There is a brief account of it in the "Revista do Instituto Historico do Brazil," Vol. XXXVIII., 348–349.

The writer of this review went to Diamantino in 1882 with the purpose of descending the Arinos and Tapajos to Santarem. There was a regular traffic on the river, and during his short stay at Diamantino a canoe loaded with guaraná arrived from the lower river. The voyage was not made, however, for the simple reason that the canoemen were in debt at Diamantino, and their creditors would not allow them to leave unless their debts, amounting to several thousand dollars, were paid.

If it is too much to expect that the writer of such a book should take the trouble to acquaint himself with the older literature of the subject, surely it is not unreasonable to expect him to look through the indexes of the Royal Geographical Society of London in order to find out whether the region he traversed was unknown. Volume thirty-two of the *Journal* of that society, pages 268–280, contains an account by Chandless of his trip down that river more than fifty years ago, together with his determinations of latitudes and longitudes.

Inasmuch as but little is known of the details of the geology of the region between Goyaz and Cuyabá, the reviewer was much interested at first in the lava flows, ashes, volcanoes and craters reported across Goyaz and Matto Grosso (pages 171–291). These phenomena were quite unexpected, and their mention on almost every page led to suspicion first, and later to a comparison with the notes of the trip across the same region made by Castelnau in 1844. Evidently the author mistook for volcanic phenomena the iron cemented rocks known in Brazil as *canga*. The book fairly swarms with such absurdities and half truths.

Pages 181 to 230 of volume I. are devoted to the Bororó Indians, their customs and legends. One is amazed at the great amount of material gathered by a person who knew nothing of the language. The length of his stay among them is not definitely given, but he left them before May 20 (p. 233), and as he had entered Matto Grosso May 11, it is clear that he was with the Bororós less than a week.

The trip down the Arinos and Tapajos was one long series of difficulties in passing falls and trouble with his men. On the lower Tapajos he left the river and struck out afoot through the forests, and, as one would expect, he was soon in trouble again with his men, and out of food in addition to the inconveniences naturally to be expected in such a region.

From a scientific point of view such a book is not worthy of review space. The cosmic and ethnologic theories propounded in the preface, and the evidence on almost every page of untrustworthiness of statement put it quite out of the rank of books that can be regarded as contributing to any branch of science. It is a great pity that so much energy and money should have been expended to such little purpose.

By his own confession he could not control his men, and the reader is constantly wondering how long such an expedition can hold together, and whether the author will starve to

death or get drowned or killed right away or a little later on.

That he underwent great inconveniences and sufferings goes without saying. Such a trip can not be made in a tropical country without them; but it is questionable whether readers should be bothered with his mosquitoes, his ants, his cattle ticks, and his runaway mules.

The photographs are the one redeeming feature of the book. J. C. BRANNER

A Text-book on the Teaching of Arithmetic. By A. W. STAMPER. New York, American Book Co. Pp. 1 + 284, including bibliography and index.

This book is a real contribution to pedagogy, for although its author disavows novelty in theory and completeness in scope, he has come nearer to writing a text-book in the teaching of arithmetic for beginners than has any other writer. It differs from the other excellent works on the same subject, such as those listed in the author's bibliography, in that it gives more space to instruction in the details of method and in class-room practise than to inspirational matter. It summarizes and applies the results of pedagogical research instead of dwelling upon their origin. In comparison with other books on the teaching of arithmetic, it is a manual of method rather than a reference book for the teacher's professional library.

As to its fitness for this purpose, it covers well the courses in the teaching of arithmetic given in our better normal schools. It is a well-rounded and well-balanced treatment of school. It is in general accurate as to fact, and sound in doctrine. The author has profited by his labors at Teachers College, Columbia University, particularly by his access to the great collection of original arithmetical works gathered there. These sources, supplemented by the accurate digests and classifications, and the collections of related mathematical apparatus, constitute the most significant assemblage of historical material on the subject of arithmetic to be found anywhere in the world.

But with all this the book is a chart of the beaten path. It will serve to help the laggards rather than to blaze a new trail. To some the book will seem to be written wrong end to. As it stands the order of discussion is: Origin (Chap. I.), Logic (Chap. II.), Subject Matter (Chaps. III.–VI.), Method (Chaps. VIII.–X.), Purpose (Chap. XI.). But among these topics why should not the last be first? The author makes aim or purpose the first consideration in his typical method lessons, and states (pp. 248–249) the controlling aim in the teaching of arithmetic. If the discussion of the selection, presentation and study of subject matter had been controlled from the start by the real *purpose*, it would not have greatly modified the conclusions of this volume. But it would have thrown a flood of light on why we are told to teach or not to teach certain things, and why we are told to teach in a prescribed way. The subject, if approached from this stand-point, would necessitate discussing, to a greater extent than the author does, the attitude of the pupil, who, after all, is the first consideration, the chief beneficiary and the sole legatee in the teaching of arithmetic.

The following more specific references may be of value: Pp. 9–18: A pragmatic treatment such as indicated above would relegate these meager nine pages of history to subordinate notes under related topics in later chapters. P. 18, questions 5 and 6, are of little value. P. 20: The *working* definitions explained at the bottom of the page should be emphasized as the kind of most value in arithmetic. P. 29: It would help the teacher, if the author had admitted that counting is measuring in the broadest sense. P. 30: the last paragraph could be strengthened thus: To the statement, "The multiplicand and the product being concrete," add "and of the same kind." Also to the statement, "The dividend is always concrete," should be added, "if either of the other terms are." P. 43: Young teachers may be led to overvalue work in artificial scales. P. 44: The expression, "When the first nine," would better be "when the column at the left." P. 51: The teaching of casting out nines is of doubtful value as a pratical check required in the universal course of study. P. 58: Re-

mainders should be taught before formal division. Thus, when the pupil knows that four sevens are twenty-eight, he should learn that thirty is four sevens and two units remaining. P. 63: The Euclidean method of greatest common divisor is referred to without explanation. P. 74, last paragraph of the example: The reason "Since we get the same answer . . ." is not sufficient and is inexcusable because the real reason is so apparent. In the process of reducing the fractions to their common denominators the numbers 8 and 9 are actually found thus, 4×2, 3×3. P. 99: This is too advanced to be of practical value in the grades. P. 101, last paragraph: Although the author has good precedent for this, it is surely a perversion to teach that "hundredths" and "per cent." are interchangeable. For if so, then 7.07 per cent. could read seven and seven per cent. per cent., an unfortunate confusion. Per cent. is primarily a rate per hundred, and its presentation as such would not exclude the desirable things in the author's subsequent treatment. P. 110 (*a*): "Times greater than" is a loose use of language for "times as great," probably due to the author's effort to carry out an analogy to percentage. Pp. 109–111: This correspondence between percentage and the processes with integers and fractions is not sufficiently significant to warrant its use in the class-room, and is of little value to the teacher. Pp. 126–135: The explanations on these pages are rather complicated, and, taken as a whole, are not teachable in the class-room. It would be better to point out for the teacher exactly the form to be used. Pp. 148–152: One is disappointed not to find a reference to the modern partial-payment problem most frequently met; namely, the one in which limited payments are accepted at stated intervals, usually at interest dates. Pp. 180–181: An expansion and illustration of this topic would be of greater value than the familiar material on pp. 172–175. Chapters VIII.–IX., pp. 196–233, are Herbartian and discuss the teaching process from the standpoint of the subject, instead of from the standpoint of the pupil. Pp. 200–201: The teacher's aim is relatively unimportant. It is the pupil's purpose that controls his activity. Consequently he must have a stronger motive than that suggested at the end of p. 201. In this connection, compare pp. 201 and 203 with the more helpful suggestions on pp. 212 and 218. Pp. 236–242: these lists impress one as more complete than significant. The points made need classifying. The young teacher should be told which of these are most important. It is better to study a few essentials of a model lesson, than to attempt so ambitious a list. Pp. 243–277: Chapter XI. is wholly inadequate, especially in its treatment of the curriculum. The vital question to-day is not, "How shall we parcel out the body of arithmetical science?" but, "What live issues, appreciated by children, shall we choose as the core of instruction?" The curriculum must precede method, hence the prospective teacher should be instructed to observe this order in teaching. Pp. 278–280: Since many of our normal students take one or two modern languages, a few references to foreign works on the teaching of arithmetic might be helpful, particularly the German works of Unger and Knilling.

The foregoing criticisms should not be taken as the estimate of the book. The volume is packed with good suggestions to teachers, and will take its place among the most useful half-dozen available books on the subject.

Lambert L. Jackson

Montclair, N. J.,
January 3, 1914

Guide to the Study of Animal Ecology. By Chas. C. Adams. New York, Macmillan. 183 pages.

This book is essentially a bibliographical and methodological manual for field students in ecology. As is stated in the preface the primary emphasis is upon ecological survey work. Thus instrumental measurement of the environment and experimental study are elaborated in the literature cited. The following chapter headings appear: Aim, Content and Point of View; The Value and Method of Ecological Surveys; Field Study; The Collection, Preservation and Determination of Specimens; Scientific Technique; Sources of Information on

Life Histories; Environmental Change; Metabolism, Growth, etc.; Adjustment between the Environment and Animal. Its scientific value lies in the author's outline for the organization of the science.

In the first chapter, the subject is divided into "individual ecology" or the ecology of individuals and species, and "aggregate ecology," or the ecology of taxonomic groups of species, genera, families, etc. These two divisions have usually not been recognized separately. The distinction is good, but the two divisions taken together are coordinate with his third division, "associational ecology," or the ecology of communities. Chapters II.–IV. are devoted to ecological surveys and methods of conducting them. The author rightly deplores the tendency of museums to rate the work of collectors and expeditions on the basis of number of specimens brought back, as this discourages the recording of ecological facts. The methods of collecting, preserving and arranging notes and specimens, and securing proper identification of the latter are given. These chapters will be of material aid to those undertaking field ecological study.

Although divided under several chapter headings, the remainder of the book consists essentially of about 90 pages of classified bibliography. The references are of a diversified type and are intended to guide the worker to needed information, ranging from the making up of the sometimes necessary camping outfit, to the preparation of his results for the printer. They are classified under general headings and many are followed by statements as to contents. Representative papers on the environment, animal communities, struggle for existence, physiology, behavior and many other topics are included. The references are complete enough to give valuable suggestions to workers from almost any point of view in ecology. The comments on the more important older ecological papers make it clear that a considerable number of incomplete attempts at organization of knowledge of animal communities have been recorded. Thus by means of the references, the book gives the history of the development of the science.

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SPECIAL ARTICLES

THE "GOLDEN MEAN" IN THE INHERITANCE OF SIZE

IN bulletin 242 of the New Jersey State College Experiment Station, page 39, appears the following statement:

> The size and shape of the F_1 (tomato) fruits are the geometric means between the size and shape corresponding to those factors of the parents, which were active in crossing.

This statement was based upon the measurements of many thousands of tomato fruits. A mode of inheritance in which $x(F_1) = \sqrt{ab}$ assumes that in the union of gametes representing factors for size a multiplication and the extraction of a square root take place. I was unable at the time to explain how that might occur, and so far no attempt by any one else to interpret the significance of my results has come to my notice. In a forthcoming bulletin I shall present details of F_2 and F_3, and this paper is published solely to set forth the nature of the principle of size inheritance by the "golden mean," to indicate its bearing upon vital questions on subjects in heredity, and to establish the priority of its discovery.

When two factors for different sizes of homologous parts meet in a cross, the resulting F_1 size is commonly intermediate in such parts as are not greatly subject to fluctuation. If a and b represent the parental size characters, it has been tacitly assumed by most investigators that the F_1 size is $(a+b)/2$. In tomato fruits I found it to be $\sqrt{ab}$. On the face of it the average (algebraic mean) seems the more probable, but when used as the basis for the comparable inheritance of lines, surfaces, and volumes, it becomes impossible. For example, let plants be crossed, which have spherical fruits of diameters a and b, and let us assume, for the sake of simplicity, that all cells constituting the volumes of both fruits are of equal dimensions. Then the ratio between parents and F_1 of the number of cells

forming any diameter one cell in thickness would be as $a:(a+b)/2:b$; the ratio between the cells making up the surface (epidermis) of the respective fruits would be as $a^2:[(a+b)/2]^2:b^2$; while the ratio between the number of cells constituting the entire volume would be as $a^3:[(a+b)/2]^3:b^3$, all of which ratios are different. It is evident, however, that any cell might be cut by a diameter and that the surface cells are part of the volume. The size inheritance of an epidermal cell might fall under either of these three ratios, depending on which aliquot part of the fruit was under study. If there is inheritance of the nature $x=(a+b)/2$, it is not clear why the diameters and not the surfaces or volumes should fall under that principle. If one does, the other two can not.

If it be assumed, under like conditions, that $x=\sqrt{ab}$, the ratio between parents and F_1 of the number of cells forming a diameter one cell in thickness becomes $a:\sqrt{ab}:b$; that between the surface cells $a^2:ab:b^2$; and that between the total cells in the volume of the sphere $a^3:ab\sqrt{ab}:b^3$. These three ratios are all equal to $a:\sqrt{ab}:b$, if a and b mean the respective parents, so that no matter what aliquot part of the fruit is under study, the ratio of size inheritance of lines, surfaces, and volumes would be the same. Surely this appears the more probable.

But how can a plant extract the square root of a product? For the sake of convenience in demonstration let us assume that the fruits are cubes instead of spheres, that all cells are equal and of size 1, and that parental characters of size are 4 and 9. Then the length factor of the F_1 would be made up of two forces, one tending to build strings of four cells in the direction of the longitudinal axis, the other tending to build strings of nine cells. Similarly, the breadth factor would be made up of two such forces building at right angles, and in the same way the factor for thickness at right angles to both. Constituent 4 of the length factor, coming from one parent and constituent 9 of the breadth factor coming from the other parent may then be imagined as building at right angles to each other, in strings of nine in one direction, in strings of four in the other. The respective partners of the two factors would be similarly engaged, and likewise the two length factors with those for thickness and the two breadth factors with those for thickness. Each set of two would tend to build rectangles of the dimensions $9\times4=36$. If now there were some force stronger than the tendency of the size factors, which would prevent the formation of rectangles and permit only squares, while having no influence on absolute size, area, or volume, the sets of size factors would be forced to modify the shape of their structures, making squares instead of rectangles. Since the modifying force did not influence area, the resulting squares would also be of the area 36, their sides 6, and the cubical fruits $6\times6\times6=216$. This modifier of size is the factor for shape. When both parents carry only the factor for cubical shape, the F_1 fruits are cubical, no matter what the tendencies of the size factors.

In spheres the diameters are directly proportional to the sides of equal cubes; so that what applies to cubes in this respect, applies to spheres as well. The factor for spherical shape is the modifier of the interaction of the factors for absolute size.

At first sight it may seem as if the fact that the size of the F_1 is the golden mean between the parental sizes can be of little value beyond furnishing an explanation of partial dominance in the F_1. However, the recurrence of the action of the modifier (shape) upon the various size combinations in the F_2 interferes greatly with the chances for the appearance of certain visible size characters.

We know that size characters do segregate in the F_2, but we admit that with them the simple Mendelian ratio of 1:2:1 is never realized, though in large populations the parental sizes may reappear. Mendelians commonly try to account for the complicated ratios by assuming the presence of multiple factors; non-Mendelians point to the same ratios as quasi-evidence against Mendelian inheritance. I here offer a different explanation.

In the F_1 fruit $6\times6\times6$ the size character 6 is not the result of a factor for size 6, but of the three forces exerted by two size factors and

one modifier. It has not been assumed in the above explanation that the partners in an F_1 "factor" fuse to make a new factor. Thus we have to deal in both ♂ and ♀ gametes produced by the F_1 with factors 4 and 9 for each of the three size factors, length, breadth and thickness, occurring in equal numbers, and mating by chance (in self-fertilization). This is the same assumption made by Mendelians, even if they should not admit the F_1 inheritance of $x = \sqrt{ab}$. There would be these eight possible combinations uniting with each other by chance:

Combination	Length	Breadth	Thickness
1	4	4	4
2	4	4	9
3	4	9	4
4	9	4	4
5	9	9	4
6	9	4	9
7	4	9	9
8	9	9	9

These would result in the following 64 matings:

Mating	Resultant	Volume
1 × 1	4 × 4 × 4	64
1 × 2	4 × 4 × 6	96
1 × 3	4 × 6 × 4	96
1 × 4	6 × 4 × 4	96
1 × 5	6 × 6 × 4	144
1 × 6	6 × 4 × 6	144
1 × 7	4 × 6 × 6	144
1 × 8	6 × 6 × 6	216
2 × 1	4 × 4 × 6	96
2 × 2	4 × 4 × 9	144
2 × 3	4 × 6 × 6	144
2 × 4	6 × 4 × 6	144
2 × 5	6 × 6 × 6	216
2 × 6	6 × 4 × 9	216
2 × 7	4 × 6 × 9	216
2 × 8	6 × 6 × 9	324
3 × 1	4 × 6 × 4	96
3 × 2	4 × 6 × 6	144
3 × 3	4 × 9 × 4	144
3 × 4	6 × 6 × 4	144
3 × 5	6 × 9 × 4	216
3 × 6	6 × 6 × 6	216
3 × 7	4 × 9 × 6	216
3 × 8	6 × 9 × 6	324
4 × 1	6 × 4 × 4	96
4 × 2	6 × 4 × 6	144
4 × 3	6 × 6 × 4	144
4 × 4	9 × 4 × 4	144
4 × 5	9 × 6 × 4	216
4 × 6	9 × 4 × 6	216
4 × 7	6 × 6 × 6	216
4 × 8	9 × 6 × 6	324
5 × 1	6 × 6 × 4	144
5 × 2	6 × 6 × 6	216
5 × 3	6 × 9 × 4	216
5 × 4	9 × 6 × 4	216
5 × 5	9 × 9 × 4	324
5 × 6	9 × 6 × 6	324
5 × 7	6 × 9 × 6	324
5 × 8	9 × 9 × 6	486
6 × 1	6 × 4 × 6	144
6 × 2	6 × 4 × 9	216
6 × 3	6 × 6 × 6	216
6 × 4	9 × 4 × 6	216
6 × 5	9 × 6 × 6	324
6 × 6	9 × 4 × 9	324
6 × 7	6 × 6 × 9	324
6 × 8	9 × 6 × 9	486
7 × 1	4 × 6 × 6	144
7 × 2	4 × 6 × 9	216
7 × 3	4 × 9 × 6	216
7 × 4	6 × 6 × 6	216
7 × 5	6 × 9 × 6	324
7 × 6	6 × 6 × 9	324
7 × 7	4 × 9 × 9	324
7 × 8	6 × 9 × 9	486
8 × 1	6 × 6 × 6	216
8 × 2	6 × 6 × 9	324
8 × 3	6 × 9 × 6	324
8 × 4	9 × 6 × 6	324
8 × 5	9 × 9 × 6	486
8 × 6	9 × 6 × 9	486
8 × 7	6 × 9 × 9	486
8 × 8	9 × 9 × 9	729

Among the possible combinations there are 16 in which both ♂ and ♀ have furnished the factor for length 4, and it has been commonly assumed that therefore one quarter of the F_2

population should show the character of length 4. The column of volumes, however, shows that there is only one out of the 64 with a volume 4^3. All others with factors for length four have larger volumes, because their factors for breadth and thickness are greater than four. Here again the law of the golden mean is followed as all combinations bearing unequal size factors are forced to build cubes by the modifying factor shape. Evidently all matings resulting in equal volumes will make equal cubes and therefore show equal characters of length, breadth and thickness, though not necessarily possessing equal size factors nor even the factor for the size which they exhibit. If we group the results by volume and length of side, we have:

Volume	Instances	Side of Cube
64	1	$\sqrt[3]{64} = 4.$
96	6	$\sqrt[3]{96} = 4.57 -.$
144	15	$\sqrt[3]{144} = 5.25 +.$
216	20	$\sqrt[3]{216} = 6.$
324	15	$\sqrt[3]{324} = 6.87 +.$
486	6	$\sqrt[3]{486} = 7.86 -.$
729	1	$\sqrt[3]{729} = 9.$

That means that the chance for a parental size (whether line or surface or volume) to reappear is only 1:64 instead of 1:4. Moreover it is clear that each of the 8 possible combinations given on page 7, when mating with its like, will breed true to all three size characters, and continue to breed true thereafter if selfed. That means that these matings will form constant races, viz.:

Mating	Resultant	Volume	Size
1 × 1	4 × 4 × 4	64	4
2 × 2	4 × 4 × 9	144	5.25
3 × 3	4 × 9 × 4	144	5.25
4 × 4	9 × 4 × 4	144	5.25
5 × 5	9 × 9 × 4	324	6.87
6 × 6	9 × 4 × 9	324	6.87
7 × 7	4 × 9 × 9	324	6.87
8 × 8	9 × 9 × 9	729	9

Besides the parent-like strains then, we shall seemingly have two other races, one of volume 144, size 5.25, the other of volume 324, size 6.87, which will continue to breed true if selfed. Each of these strains consists of three gametically different, though visibly indistinguishable lines, which when crossed will give an F_1 equal to both parents, but segregating to some extent in the F_2. The finding in the F_2 or later generations of lines which breed true to size characters is thus not proof of the presence of multiple size factors in the original parents, etc.

In the bulletin in preparation I intend to discuss the bearing of the law of the golden mean upon the interpretation of inheritance of shape and number, mutants, latent factors, inhibitory factors, coupling and repulsion, factors other than those of size, shape, and number, and other points as they may come up, but for the sake of science I invite investigation into these relationships on the basis I here offer, even before I am able to publish the bulletin, which may not appear for several months.

B. H. A. Groth

"The Lowest Temperature Obtainable with Ice and Salt"

Fahrenheit placed the 0° mark on his arbitrary thermometer scale at "the lowest temperature obtainable with ice and salt" or 32° below the freezing point of water, believing that water did not have a constant freezing point because of the undercooling which precedes solidification.[1]

While discussing freezing mixtures with a friend recently I stated that a temperature of —19° C. could be *easily* obtained and maintained for some hours with an ice and salt mixture. My friend questioned the accuracy of the thermometer inasmuch as —19° C. is below 0° F. (0° F. = —17.78° C.). I have, therefore made a careful test to ascertain whether an ice and salt mixture may not show a lower temperature than 0° F.

About a gallon of finely chopped, hard, ice was mixed with a quart or more of coarse salt in a water-tight wooden box, the wooden box being used because of the insulation which it

[1] See Encyclopedia Britannica, 11 ed., "Heat," article 2.

afforded. The temperature was then observed with five thermometers:

Thermometers 1 and 2 were "nitrogen filled" thermometers graduated in Centigrade degrees ranging from —29° to +360° in 1° intervals. These are the ordinary high-grade laboratory thermometers.

Thermometer 3 was a small "Anchutz normal" thermometer reading from —25° to +50° in 1/5° intervals. This is one of the most accurate types of chemical thermometers obtainable.

Thermometer 4 was a large thermometer of the same type as No. 3, but reading from —19° to +360° in 1/5° intervals.

Thermometer 5 was an ordinary Six's maximum and minimum thermometer graduated in degrees Fahrenheit, each graduation representing 2°.

Thermometer 6 was a standard Weather Bureau type minimum thermometer reading from —35° to +115° F. in 1° ranges. This is probably one of the most accurate types of Fahrenheit thermometers obtainable.

Thermometer No. 6 was spirit filled. No. 5 contained a combination of spirit and mercury and all of the others were mercury filled.

Thermometers 1, 2 and 3 gave the same temperature for the ice and salt mixture, *i. e.*, —21° C. which is the equivalent of 5.8° *below zero* Fahrenheit. Thermometer 4 was graduated only to —19° C. and the mercury was some distance below the bottom of the scale. By interpolation a reading of —20° to —21° C. was made. Thermometer 5 gave a minimum of —4° F. while the Weather Bureau thermometer (No. 6) gave a reading of —5° F.

Previous to this experiment I had filled a wooden box holding perhaps 30 pounds of ice with a freezing mixture in the evening and placed it in an empty ice box to conserve ice. In the morning I noted a temperature of —19° C. (—2.2° F.).

From these experiments I am convinced that 0° F. is not "the lowest temperature obtainable with ice and salt." Just what the "lowest temperature" is I am unable to state, having failed to secure a greater lowering than —21° C. Theoretically the lowest temperature should be the cryohydric point (—22° to —23° C.) where the cryohydrate, ice and salt containing 23.6 per cent. of NaCl, separates.

ROSS AIKEN GORTNER

THE AMERICAN PETROLEUM SOCIETY

THE American Petroleum Society was organized September 10 at the U. S. Bureau of Mines, Pittsburgh, Pa. This organization is the result of an effort of the bureau for the past seven years to bring together the men interested in the petroleum industry.

Invitations were sent out in July to the secretaries of twenty-four of the great national societies of the United States, inviting them to be present and to cooperate in this organization. Eighteen of these societies responded at a meeting on August 1 at the Bureau of Mines. A similar invitation was sent out in August to eight additional societies, making a total of thirty-two societies that were invited to attend the September conference. A large number of these were represented at the meeting on September 10, when the final organization was completed.

This society will concern itself with the study of all phases of natural gases and petroleums, including the origin, statistics, conservation, drilling methods, production, transportation, storage, refining and specifications for refined products.

When it is considered that each year, within the United States alone, there are produced crude petroleums and natural gases having a value in excess of $200,000,000, and that no society has ever been organized in America for their comprehensive study it is reasonable to suppose that the future of this society is assured. There is to-day a tremendous waste of natural gases which, by proper methods of drilling, could be prevented. Also, there is waste of crude oil due to improper methods of production and handling. The necessity for a critical study of petroleums and gases by the members of such a society is evident.

At the meeting on September 10 at the Bureau of Mines the constitution and by-laws were adopted, and officers were elected as follows:

President, C. D. Chamberlin, National Petroleum Association, Cleveland, Ohio; *Vice-president,* R. Galbreath, Independent Oil and Gas Producers' Association of Oklahoma, Tulsa, Okla.; *Secretary,* Irving C. Allen, U. S. Bureau of Mines, Pittsburgh, Pa.; *Treasurer,* Warren C. Platt, Independent Petroleum Marketers' Association of the United States, Cleveland, Ohio; *Acting Past President,* Frank B. Fretter, Western Petroleum Refiners' Association, Coffeyville, Kansas. In addition to the foregoing these members were also elected to serve on the executive committee: Ralph Arnold, Geological Society of America, Los Angeles, Cal.; C. F. Clarkson, Society of Automobile Engineers, New York City; G. M. Swindell, Chamber of Mines and Oil, Los Angeles, Cal.; Edmund O'Neill, American Chemical Society, University of California, Berkeley, Cal.; E. B. Rich, Gasoline Producers' Association, Parkersburg, W. Va.; George H. Taber, American Society for Testing Materials, Pittsburgh, Pa.

The first annual meeting will be held at New Orleans, La., October 16 and 17, 1914, and the second annual meeting will be held at the Panama-Pacific International Exposition in San Francisco, October 25 to 30, 1915. At the 1915 meeting it is anticipated that all of the petroleum societies in the country will meet in one great congress where many things of interest and of value will be presented.

An official invitation has been sent from the president of the Exposition at San Francisco to the president of the International Petroleum Commission, Karlsruhe, Germany, to hold the 1915 meeting of the International Petroleum Commission in San Francisco. This meeting will be part of the great meeting of the petroleum industries where the foremost petroleum technologists and scientists of the world will congregate. Plans are already being formulated for this great 1915 meeting.

Irving C. Allen

Bureau of Mines

THE AMERICAN BISON SOCIETY

At the annual meeting of the American Bison Society, held in New York on January 8, 1914, important action was taken relative to extending the work of the society by the passage of the following resolution, proposed by Professor Henry Fairfield Osborn and seconded by Dr. Wm. T. Hornaday:

Resolved, That the protection and propagation of the prong horn antelope be immediately undertaken by the American Bison Society in connection with its work for the buffalo, and that the board of managers be asked to request the president and officers to formulate and execute a plan whereby this purpose may be carried out.

At the annual meeting of the board of managers, after a brief discussion of this matter, the president and executive committee were instructed to take such action as they might deem best as soon as possible.

President Hooper, in his annual report, gave an interesting summary of the work already accomplished by the society, and pointed out several directions in which effort should be directed during the coming year. He called attention to the fact that when the society was organized some eight years ago only 1,100 pure-blooded bison were known to exist in North America, while on January 1, 1913, 3,453 animals were listed in the census compiled by the society, an increase of over 300 per cent. During the past year the Wind Cave National Game Preserve has been established at the instance of this society, and has been stocked with fourteen bison presented by the New York Zoological Society from its herd in the Bronx Park.

The work awaiting the society during the coming year was listed by President Hooper under three heads: (1) The establishment of a herd in Sully's Hill National Park, North Dakota, (2) the establishment of a state herd in New York state or elsewhere, (3) encouragement of the preservation of the prong horn antelope, and possibly of other species of big game animals.

Dr. T. S. Palmer, of the U. S. Biological Survey, called attention to the possibility of establishing a state herd in West Virginia on the preserve of the Allegheny Sportsmen's Association. He also stated that the Montana, Wind Cave, Niobrara and Wichita ranges were all well suited to antelope.

It was felt that the society could well take pride in its recent achievements, but that its efforts must not in any way be relaxed during the coming year.

William P. Wharton,
Secretary